FINAL REPORT (July 1993)

Project Number: FV42

Project Title: Aphids: Protection of Lettuce and Brassicas

Project Leader: Mr D L Suett

Project Location: Horticulture Research International, Wellesbourne

Project Co-ordinator: Mr A Whitlock

Date Project commenced: 1 July 1990

Date Project completed: 30 June 1993

Key words: Brussels sprouts, lettuce, aphids, brassicas, disulfoton, demeton-S-methyl

INDEX

PRACTICAL SECTION

FOR

GROWERS

Control of cabbage aphid on brassicas

SUMMARY

The effectiveness of disulfoton and demeton-S-methyl against cabbage aphid has been examined in a 3-year study.

On spring cabbage, early summer cauliflower and early-, mid- and late-season Brussels sprouts, prolonged control was achieved by applying a sub-surface band of disulfoton at sowing or planting.

With all crops, residue concentrations at harvest were always well below the MRL and, in most cases, were close to or less than the limits of detection.

Deep side-placement of disulfoton several weeks after transplanting a mid-season Brussels sprout crop achieved prolonged and effective aphid control with greatly-reduced operator exposure.

BACKGROUND

Infestations of aphids continue to cause problems on a wide range of vegetable crops. Inadequate control results in reduced crop quality, especially in brassicas where the yield of marketable crops may be reduced by plant malformations, the spread of aphid-transmitted viruses and the presence of aphids in produce. Although effective chemical aphicides are readily available, there is increasing concern that residues may be present in mature crops at levels which are unacceptably large. This 3-year study was done to establish or confirm treatment strategies which achieved and maintained effective control and, at the same time, presented minimum risks to operators and consumers.

FIELD TRIALS

These were based on disulfoton and demeton-S-methyl which are, respectively, the most persistent granule- and liquid-formulated aphicides available currently to UK growers. Aphicide performance and behaviour was assessed at different times of year using early summer cauliflower, early-, mid- and late-season Brussels sprouts and autumn-sown spring cabbage.

Spring cabbage

Despite heavy infestations of cabbage aphid in late summer and early autumn, a single sub-surface band application of disulfoton FE.10 at sowing time in early August kept plants aphid-free until the following spring. Residues in the mature plants were less than 0.01 mg/kg.

Early summer cauliflower

Disulfoton FE.10, applied as a sub-surface band at transplanting in mid-May, kept plants aphid-free until harvest in early August, 12 weeks after planting. Residues in these plants were less than 0.01 mg/kg.

Brussels sprouts

The prolonged effectiveness of a sub-surface band of disulfoton FE.10 applied at transplanting was further demonstrated in trials with early-, mid- and late-season Brussels sprouts. In general, a 2-3 month period of total protection was ensured, with the exact duration depending on weather conditions, which affected infestation levels as well as influencing the availability of the aphicide and its distribution within the plant. As the efficacy of soil treatments diminished, aphid control was prolonged very effectively by foliar application of either disulfoton P.10 granules or demeton-S-methyl. Disulfoton P.10 was always the more effective treatment, protecting the crop for 2-3 times longer than a simultaneous application of demeton-S-methyl. On all occasions, residues of disulfoton, or of disulfoton + demeton-S-methyl, in mature, marketable sprout buttons, were at, or little more than, the limits of detection and were well below the maximum residue limit (MRL), for both insecticides, of 0.5 mg/kg.

The experiments thus confirmed that prolonged and effective control of cabbage aphid on a wide range of brassicas could be achieved by establishing a treatment regime based on a sowing- or planting-time application of disulfoton FE.10 granules. Furthermore, this protection was achieved without any risk of unacceptable residues remaining in the mature crops - almost without exception, residue concentrations at harvest were only 1-2% of the MRL.

Nevertheless, despite this extensive evidence of treatment efficacy and consumer safety, growers continued to express concern about the practical use of disulfoton. They were concerned especially about two aspects, namely:

1. Operator safety - despite re-assurances about the unlikelihood of exceeding Occupational Exposure Standards (OES), many growers were anxious to limit, and if possible avoid, exposure of their operators to insecticide vapours during the planting operation.

2. Availability during prolonged dry spells - without irrigation, uptake from a placement in the 0-5 cm-deep soil layer could quickly become limited.

A study was therefore done in the final year of the project to explore the feasibility of applying disulfoton FE.10 as a deep side-placement along the row several weeks after planting.

LATE DEEP SIDE-PLACEMENT

In the absence of commercially-available equipment for the deep side-placement of granular formulations, a system was designed and constructed at HRI-Wellesbourne. A standard coulter blade was bent to an angle of 38° from the vertical and 16 mm i.d. mild steel tubing was attached to the trailing edge (see Figure 1). The coulters were fitted on to a Stanhay drill unit, which permitted accurate side-placement (relative to the plant rows) as well as depth adjustment. The treatments were applied 0, 3, 5 and 7 weeks after planting and placements ranged from 10 cm deep x 10 cm from row centre up to 15 x 20 cm (Figure 2). The performances of these treatments were compared with that of a sub-surface band of disulfoton FE.10 applied along the row at transplanting in mid-May.

The most effective treatments were the deep side-placements applied 5 weeks after planting. The 10 x 10 cm placement kept buttons aphid-free until the end of September and less than 2% were infested during October. In contrast, 8-10% of buttons from the sub-surface band treatment, and 20-25% from the earliest (0 weeks) deep side-placement, were infested by early autumn. Analyses of sprout buttons sampled from September to December showed that residue concentrations in all treatments were always less than 0.01 mg/kg.

CONCLUSIONS

Late deep side-placement of disulfoton FE.10 to Brussels sprouts:

* prolongs the availability of insecticides to the plant roots
* eliminates operator exposure
* produces negligible residue levels in the mature crop

HOWEVER, growers should be aware that:

* the above study was done on a trial-size plot - field-scale studies should be done to confirm the commercial practicality of the technique
* effects on crop yield were not established
* in 1992, abundant rainfall from July onwards would have ensured that insecticide availability and uptake was near-optimal - performance in a drier year has not been established

Control of foliar aphids on lettuce

SUMMARY AND CONCLUSIONS

The field studies in 1990 and 1991 confirmed the prolonged efficacy of demeton-S-methyl against foliar aphids on lettuce. Complementary residue studies showed that, with the exception of the earliest (April) planting, residue concentrations in the mature plants were always below the MRL of 0.5 mg/kg within 21 days of treatment, irrespective of plant growth stage at the time of application.

It was concluded that residue problems with this crop/insecticide combination should be unlikely in all except the earliest outdoor plantings - when prolonged protection is seldom necessary - provided the stipulated interval of 21 days between last application and harvest is observed.

SCIENCE SECTION

INTRODUCTION

Infestations of aphids, including leaf- and root-feeding species, continue to cause problems on a wide range of field vegetables. A succession of mild winters has enabled aphids to overwinter as active stages as well as in the egg stage and colonies have built up rapidly under the warm, dry conditions that have been experienced recently in the UK. Inadequate levels of control have resulted in reduced crop quality, especially in brassicas and lettuce where the yield of marketable crops has been reduced by plant malformations, by the presence of aphids in produce and by aphid-transmitted viruses. There is also increasing concern that aphicide residues in some crops may be present at unacceptably-large levels.

The major objective of the present study was therefore to identify and define optimum strategies for the use of available aphicide treatments on brassicas and lettuce. These strategies would cover the annual cropping schedule and, where appropriate, would be integrated with non-chemical strategies emerging from current MAFF-funded projects which have been established to evaluate their potential.

The field studies and the associated residue analyses were done at Horticulture Research International, Wellesbourne (HRI-W). The progress and direction of the project was reviewed and discussed regularly with HDC and with representatives of the brassica-growing industry. The consequent emphasis on the evaluation of chemical strategies resulted primarily from the identification at these meetings of immediate market requirements and also from the unavailability of practical non-chemical strategies.

MATERIALS AND METHODS

Field Experiments

Experiment No.	Brief Title	Crop
A. 90114	Control of cabbage aphid on overwintered brassicas	Brussels sprouts
B. 90115	Persistence and uptake of systemic aphicides applied to outdoor lettuce	Lettuce
C. 90116	Control of cabbage aphid on spring cabbage	Spring cabbage
D. 91032	Persistence and uptake of systemic aphicides applied to outdoor lettuce	Lettuce
E. 91035	Control of cabbage aphid on early Brussels sprouts	Brussels sprouts
F. 91037	Control of cabbage aphid on summer cauliflower	Summer cauliflower
G. 91096	Cabbage aphid control - influence of spray volume	Brussels sprouts
H. 92052	Cabbage aphid control - behaviour and efficacy of late deep-side placements	Brussels sprouts

A. 90114 - Control of cabbage aphid on overwintered brassicas

Objectives: To establish the duration of effectiveness of disulfoton against cabbage aphid on overwintered Brussels sprouts

Site: Soakwaters, 23 x 20 m

Crop: Brussels sprouts cv. Edmund, raised in 2.5 cm peat blocks and treated with chlorpyrifos to control cabbage root fly. Planted 60 cm between plants, 75 cm between rows on 14 June 1990, using a Super-Prefer planter. The experiment was terminated in March 1991.

Experimental design and treatments: Two areas were established:

Area 1 comprised eight single rows of 33 plants, each row treated with a logarithmically-increasing dose of disulfoton FE.10 granules applied with a Leeds coulter, and 4 single rows of untreated plants. The direction of low → high dose was randomised. Dose ranged from 10 to 205 g product/100 m row.

Area 2 comprised 21 plots of 9 plants, representing 7 replicates of 3 treatments. All plants were treated with a sub-surface band application of the recommended dose of disulfoton FE.10 granules, equivalent to 105 g product/100 m row (14 kg product/ha at 75 cm row spacing). The 3 treatments were: 1) No further insecticide; 2) foliar application of demeton-S-methyl at recommended dose; 3) foliar application of disulfoton P-10 granules. The supplementary treatments were applied on 20 September only. Demeton-S-methyl was applied, using a hand-held sprayer, at the recommended dose, equivalent to 560 ml product (55% a.i.) in 1200 l water/ha. Disulfoton P.10 was applied at the recommended dose of 14 kg product/ha, 6.7 g granules being applied by hand to each block of 9 plants.

Records taken:

1. Weekly assessments of aphid infestations from June to mid-October: 3-4 weekly assessments from November to March.
2. Samples of sprout buttons were taken from Area 2 (fixed-dose + supplementary treatment) on 17 December and 18 February for insecticide residue analysis.

B. 90115 - Persistence and uptake of aphicides applied to lettuce

Objectives: To assess the persistence and efficacy against foliar aphids on lettuce of foliar-applied systemic aphicides and to establish the extent to which residue dissipation is influenced by application at different stages of growth and at different times of year.

Site: Rush Pits, 22.5 x 7 m

Crop: Lettuce cv. Saladin. Plants were raised in peat blocks and were hand-planted on 11 July, 9 August and 12 September 1990.

Experimental design: Three experimental areas were established (one for each planting). Each area comprised 4 replicate blocks of 5 treated plots. Each plot comprised 20 plants and plots were fully randomised within each block. Plants were spaced at 30 x 30 cm within plots, with 60 cm between plots.

Experimental treatments: All plants were sprayed with demeton-S-methyl within 24 h of planting. The following additional treatments were then applied:

1. Plants kept aphid-free with most persistent insecticide appropriate to plant growth stage.
2. No further treatment.
3. Demeton-S-methyl applied approximately 2 weeks after planting.
4. Demeton-S-methyl applied approximately 4 weeks after planting.
5. Demeton-S-methyl applied approximately 6 weeks after planting.

The exact timing of treatments 3-5 was modified according to the season. Demeton-S-methyl was applied at the recommended dose of 420 ml product/ha in a volume of water equivalent to 200 l/ha.

Records taken:
1. Weekly assessment of aphid infestations on all plants.
2. Samples for residue analysis: two plants from each replicate were removed to give a total of 8 plants per treatment per sampling occasion. Sample dates were 1 day, 1 week, 2 weeks, 3 weeks and 4 weeks after each treatment.

C. 90116 - Control of cabbage aphid on autumn-sown spring cabbage

Objectives: To develop a strategy for production of aphid-free overwintered spring cabbage containing minimal concentrations of aphicide residues.

Site: Soakwaters, 3 areas, each 17 x 20 m

Crop: Cabbage cv. Myatts Offenham Compacta, drilled at 4 rows per bed, 30 cm between rows, using a Stanhay drill on 1) 25 July; 2) 6 August and 3) 21 August 1990. Extensive and frequent irrigation was required to ensure emergence.

Experimental design and treatments: On each sowing date, two areas were established:

Area 1 comprised 7 beds, 19 m long. Four of the beds were treated with a logarithmically-increasing dose of disulfoton FE.10 granules applied by the bow-wave method (Makepeace, 1965) to each row at sowing time. The direction of low → high dose was randomised between beds. Three further beds remained untreated with insecticide.

Area 2 comprised 5 replicates of three treated plots, derived from 3 x 19 m-long beds of 4 rows. All rows received the recommended linear dose of 10.7 g disulfoton FE.10 per 19 m of row, equivalent to 56.3 g product/100 m row or 14 kg/ha at 30 cm row spacing. Beds were then sub-divided into 5 x 3 m long sections, with 1 m-pathways between sections. The three proposed treatments were intended to assess the efficacy of supplementary foliar treatments. They comprised 1) foliar application of disulfoton P.10 granules; 2) foliar spray application of demeton-S-methyl; 3) no further treatment.

Records taken:

1. Weekly assessments of aphid infestations from sowing until mid-October: 3-4 weekly assessments from November to March.
2. Samples of whole plants were taken from Area 2 (fixed - dose treatment) on 18 February for insecticide residue analysis.

D. 91032 - Persistence and uptake of aphicides applied to lettuce

Objectives: As Experiment B. 90115, extended to full season.

Site: Townsend West, 23 x 12 m

Crop: Lettuce cv. Saladin. Plants were raised in peat blocks and transplanted on 26 April, 14 May, 10 June, 1 July, 29 July and 28 August 1991.

Experimental design: Six experimental areas were established (one for each planting). Each area comprised 4 replicate blocks of 5 treated plots. Each plot comprised 20 plants and plots were fully randomised within each block. Plants were spaced at 30 x 30 cm within plots, with 60 cm between plots.

Experimental treatments: All plants were sprayed with demeton-S-methyl within 24 h of planting. The following additional treatments were then applied:

1. Plants kept aphid-free with most persistent insecticide appropriate to plant growth stage.
2. No further treatment.
3. Demeton-S-methyl applied approximately 2 weeks after planting.
4. Demeton-S-methyl applied approximately 4 weeks after planting.
5. Demeton-S-methyl applied approximately 6 weeks after planting.

The exact timing of treatments 3-5 was modified according to the season. Demeton-S-methyl was applied at the recommended dose of 420 ml product/ha in a volume of water equivalent to 200 l/ha.

Records taken:
1. Weekly assessment of aphid infestations on all plants.
2. Samples for residue analysis: two plants from each replicate were removed to give a total of 8 plants per treatment per sampling occasion. Sample dates were 1 day, 1 week, 2 weeks, 3 weeks and 4 weeks after each treatment.

E. 91035 - Control of cabbage aphid on early Brussels sprouts

Objectives:	To establish the efficacy against cabbage aphid of granular and liquid formulations of aphicides applied to early Brussels sprouts.
Site:	Little Cherry, 14 x 20 m
Crop:	Brussels sprouts cv. Dolmic, raised in 2.5 cm peat blocks and treated with chlorpyrifos to control cabbage root fly. Hand-planted 60 cm between plants, 75 cm between rows on 8 May 1991. The experiment was terminated in October 1991.
Experimental design and treatments:	The area comprised 6 replicate blocks of 3 randomised treated plots, each plot containing 9 plants. All plants were treated with a sub-surface band application of the recommended dose of disulfoton FE.10 granules, equivalent to 105 g product/100 m row. This was done by applying the insecticide via a Horstine Farmery applicator fitted with a Leeds coulter and hand-planting immediately afterwards into the row. The 3 treatments were: 1) no further insecticide; 2) foliar application of recommended dose of demeton-S-methyl; 3) foliar application of disulfoton P.10 granules. The supplementary treatments were applied on 7 August and 3 September. Demeton-S-methyl was applied, using a hand-held sprayer, at the recommended dose of 560 ml product (55% a.i.) in 1200 l water/ha. Disulfoton P.10 was applied by hand at the recommended dose of 14 kg product/ha, equivalent to 6.7 g granules per block of 9 plants.
Records taken:	1. Two-weekly assessments of aphid infestations from early July until the end of September. 2. Samples of sprout buttons were taken on 29 August and 30 September for residue analysis.

F. 91037 - Control of cabbage aphid on summer cauliflower

Objectives:	To establish the duration of efficacy of disulfoton against cabbage aphid on summer cauliflowers and to determine insecticide residue concentrations in the mature crop.
Site:	Little Cherry, 14 x 20 m
Crop:	Cauliflower cv. White Rock, raised in 2.5 cm peat blocks and treated with chlorpyrifos to control cabbage root fly. Planted by hand at 55 x 50 cm spacing, giving 3 rows per bed, on 15 May 1991. The experiment was terminated in September 1991.
Experimental design and treatments:	The area comprised 6 replicate blocks of 3 treated plots, each plot containing 25 plants. All plants were treated with a sub-surface band application of the recommended dose of disulfoton FE.10 granules, equivalent to 105 g product/100 m row. This was done by applying the insecticide via a Horstine Farmery applicator fitted with a Leeds coulter and hand-planting immediately afterwards into the row. The 3 treatments were identical to those specified for experiments A2 and E, namely disulfoton P.10, demeton-S-methyl and no further treatment.
Records taken:	1. Assessments of aphid infestations at 1-2 week intervals. 2. Samples of mature cauliflowers were taken on 23 July and 6 August for residue analysis.

G. 91096 - Influence of spray volume on aphicide efficacy against cabbage aphid

Objectives:	To assess the extent to which differences in spray volume can influence the efficacy against cabbage aphid of a single dose of demeton-S-methyl.
Site:	Deep Slade, 19 x 17.5 m
Crop:	Brussels sprouts cv. Dolmic, raised in 2.5 cm peat blocks and treated with chlorpyrifos to control cabbage root fly. Hand-planted at a spacing of 60 cm between plants, 75 cm between rows on 7 May 1991. The experiment was terminated in October 1991.
Experimental design and treatments:	The area comprised 6 replicate blocks of 4 randomised and treated plots, each plot containing 16 plants. The four treatments were based on the application of the recommended dose of demeton-S-methyl applied in 4 different dilutions with water. The initial dilutions, applied on 15 July and 7 August were: 1) 100 l/ha; 2) 300 l/ha; 3) 600 l/ha; 4) 1200 l/ha. Two further applications, on 3 September and 17 September, were at 1) 300 l/ha; 2) 600 l/ha; 3) 1200 l/ha; 4) 1800 l/ha. All the dilutions contained the same concentration of surfactant (Agral, 0.25 ml/l) and were applied using a hand-held sprayer.
Records taken:	1. Assessments of aphid infestations at 1-2 week intervals. 2. Samples of mature sprout buttons were taken on 29 August and 30 September for residue analysis.

H. 92052 - Cabbage aphid control : efficacy of deep side-placements

Objectives: To determine the efficacy against cabbage aphid of disulfoton granules applied as a deep side-placement at different intervals after planting.

Site: Wellesbourne Gravel Pits, 28 x 30 m

Crop: Brussels sprouts cv. Golfer, raised in 2.5 cm peat blocks containing chlorfenvinphos granules to protect against damage by cabbage root fly. Hand-planted at 60 cm between plants, 75 cm between rows (2 rows per bed) on 14 May 1992. The experiment was terminated in December 1992.

Experimental design and treatments: The area comprised 4 replicate blocks of 9 plots. Each plot was a single 12 m length of bed containing 2 rows of 20 plants. All the rows were treated with disulfoton FE.10 granules, applied at the maximum recommended dose of 105 g product/100 m row, at different times and in different ways. The nine treatments were:

1) Sub-surface band of granules applied via a Leeds coulter immediately before plants were hand-planted into the row (i.e. recommended procedure).
2) Placement 10 cm deep and 10 cm to one side of each row immediately after planting (0 weeks)
3) Placement 15 cm deep and 15 cm to one side of each row immediately after planting
4) 10 x 10 cm deep side-placement (DSP) 3 weeks after planting
5) 15 x 15 cm DSP 3 weeks after planting
6) 10 x 10 cm DSP 5 weeks after planting
7) 15 x 15 cm DSP 5 weeks after planting
8) 10 x 15 cm deep DSP 7 weeks after planting
9) 15 x 20 cm deep DSP 7 weeks after planting

Records taken:

1. Assessment of aphid infestations at 1-3 week intervals.
2. Samples of sprout leaves were taken at 1-2 week intervals to assess uptake of insecticide by the plants from the different treatment regimes. Samples of mature sprout buttons were taken on 27 August, 15 September, 30 September, 15 October and 3 November.

Modifications of coulter blades for deep side-placements

The lack of commercially-available equipment for the deep side-placement of granular formulations of insecticides necessitated the design and construction of a modified system by HRI-W farm staff. This was duly achieved by attaching 16 mm dia. mild steel tubing to the trailing edge of an angled coulter blade. An angle of 38° from the vertical was selected and two blades were angled in opposite directions, i.e. one to the left, the other to the right, to enable deep side-placement to be achieved with minimum plant disturbance. The coulters were attached to the horizontal framework of a Stanhay drill unit, which permitted accurate side-placement relative to the plant rows as well as appropriate depth-adjustment. In the above study, placements were made on the "inside" of each of the two rows within each bed.

General experimental details

All experiments were established at HRI-W on a light sandy-loam. All plots received a base fertiliser application (240 kg P,K/ha) before land preparation, followed by 190 kg N/ha shortly before sowing/planting. A summary of the field operations carried out by farm staff, e.g. irrigation, on each experiment is presented in Appendix 1A-1H.

Residue analyses

Sampling and sample storage

Lettuce. On each sampling occasion, two plants were taken from each of the four replicate plots within each treatment. The roots were removed in the field and the plants were washed soil-free, dried and two replicate samples/treatment were stored at -15°C.

Sprouts. Leaves were sampled from alternate plants within each treatment. On each occasion, the youngest unfurled leaf was taken and the bulked samples were stored at -15°C. Buttons were sampled by taking two marketable-size buttons from alternate plants: after assessment in the laboratory for aphid infestations, a sub-sample was chopped in a food processor before storage at -15°C.

Analytical methods

Demeton-S-methyl in lettuce

After maceration with acetone (2 x 50 mls), the filtered extract was evaporated down to an aqueous residue which was chilled, filtered and extracted with dichloromethane (3 x 25 mls). The dichloromethane was evaporated and the residue redissolved in acetone (5 mls) and oxidised with 0.1M potassium permanganate (20 mls). The

resultant demeton-S-methyl sulphone (DSM-SO_2) was extracted with dichloromethane (3 x 25 mls), the dichloromethane was evaporated and the residue redissolved in acetone.

Residue concentrations were determined by gas liquid chromatography (GC). A Packard 438 GLC was fitted with a 25 m CP-SIL-19 (Chrompack UK Ltd) widebore capillary column. Nitrogen at 8 ml min^{-1} was used as carrier gas and the injection, column and detector temperatures were 225, 155 and 250°C respectively giving a retention time for DSM-SO_2 of 3.8 minutes.

Disulfoton in sprout leaves and buttons

After maceration with dichloromethane:methanol (9:1, 100 mls), the filtered extract was evaporated to dryness, redissolved in cyclohexane:ethyl acetate (1:1, 3 mls) and cleaned up on a carbon/cellulose column (0.7 and 2.2 g respectively). The column was eluted with ethyl acetate (100 mls) which was then evaporated. The residue was dissolved in acetone, oxidised and extracted as described above for demeton-S-methyl. The disulfoton metabolites present (disulfoton, disulfoton sulphoxide, disulfoton sulphone and the oxygen analogues of these three) were oxidised to disulfoton sulphone (DSO_2) and disulfoton oxygen analogue sulphone ($DOASO_2$). Analysis of the two components was carried out using a Hewlett Packard GC fitted with a 12 m BPI (SGE) widebore capillary column. Nitrogen at 13 ml min^{-1} was used as carrier gas and the injection, oven and detector temperatures were 195, 193 and 225°C respectively giving retention times of 3.9 ($DOASO_2$) and 5.5 (DSO_2) minutes.

RESULTS

Experiment A. 90114

Cabbage aphid populations began building up on untreated plants in early July, reaching a mean level of 100 aphids per plant by mid-August and > 500 aphids/plant by the end of August.

Area 1: Figures 1 and 2 show changes in numbers of aphids on Brussels sprouts following a log-dose application of a sub-surface band of disulfoton FE.10 granules at transplanting in mid-June. Figure 1 shows results up to mid-August and Figure 2 shows results from late August until 8 October. At the recommended dose of 105 g product/100 m row, plants remained aphid-free until mid-August despite continuous drought. Following irrigation on 29 August, aphid numbers remained relatively small until mid-September on plants treated with all doses of >70 g product/100 m. Populations on all treatments up to 205 g product/100 m then increased to >100 aphids/plant by 8 October.

Area 2: Figure 3 show the gradual increase in numbers of cabbage aphid on Brussels sprouts following a single application of the recommended dose of disulfoton (105 g product/100 m row) at transplanting in mid-June. Plants remained aphid-free until mid-August, when populations began to establish and reached 20 aphids/plant by mid-September. Supplementary foliar application of disulfoton P.10 granules or a demeton-S-methyl spray reduced infestations to zero, and plants remained virtually aphid-free throughout the winter. Populations on untreated plants reached 50-60 aphids/plant by October and subsequently declined steadily.

Residues in sprout buttons

Table 1 shows residue levels in the sprout buttons sampled in December and in January. On both sampling occasions, residues of disulfoton in the plants treated at sowing time only were at or below HRI limits of detection (< 0.002 mg/kg). The supplementary treatment with disulfoton P.10 led to a 4-6 fold increase in residues but levels were still substantially below MRLs. The demeton-S-methyl treatment left no detectable residues in the buttons.

TABLE 1: Residues of disulfoton and demeton-S-methyl in sprout buttons sampled in December and February

Experiment A. 90114

BRUSSELS SPROUTS

cultivar: Edmund
planted: 14 June, 75 x 60 cm spacing
insecticide: disulfoton FE.10 at planting

Treatments

1. log-dose, 10-210 g product/100 m row
   + irrigation 29 August (11 wk)
   no further treatments

2. single-dose, 105 g product/100 m row
   + irrigation 29 August (11 wk)

   + disulfoton P.10
   OR 20 September (14 wk)
   demeton-S-methyl

Residues in button (mg kg^{-1})

Sampled	FE.10 only	FE.10[(a)] + P.10	FE.10[(a)] + d-S-m [(b)]	
			(a)	(b)
19 Dec	< 0.002	0.008	0.013	< 0.005
18 Feb	< 0.002	0.013	< 0.002	< 0.005

[(a)] determined as disulfoton oxygen analogue sulphone
[(b)] determined as demeton-S-methyl sulphone

Experiment B. 90115

Changes in concentrations of demeton-S-methyl residues in lettuce following the different applications in 1990 are shown in Table 2 and Figures 4-11. Following a single application 24 h after planting (Treatment 2, Figure 4) residues declined most rapidly in the July planting and were undetectable 14 days after treatment. Differences between the August and September plantings were comparatively small; residues were below the MRL of 0.5 mg/kg within 10-12 days and were scarcely detectable (0.02 mg/kg) after 21 days. A similar pattern emerged from Treatment 3 (Figure 5), with residues < 0.5 mg/kg after 9-12 days. However, residues in the August and September plantings declined subsequently more slowly and, after 21 days, were 0.15 and 0.06 mg/kg respectively. In the August and September plantings, initial concentrations were largest in the earlier treatments and were smallest in the plants which received a second treatment after 4 and 6 weeks (Figures 7 and 8). In the plants treated closest to harvest (Treatment 5), initial residues of 1-2 mg/kg declined to < 0.5 mg/kg within 5-6 days. Rates of residue dissipation, based on the amount of residue (mg/plant) and expressed as % of initial dose, are shown in Figures 9-11. There was a steady decline in the rate of loss as the season progressed but, in all the plantings, at least 90% of the initial deposit had been lost within 21 days of treatment.

TABLE 2: Demeton-S-methyl residues (mg/kg ± se) in lettuce following applications of 3 plantings in 1990 (Experiment B. 90115)

Treatment 2 (treated 1 day after planting)

Planting date	Days after spraying									
	1		7		14		21		28	
	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se
11 July	11.27 12.75	0.52	0.03 0.33	0.11	0.02 0.01	0.004	0.01 0.01	0	0.001 0.001	0
9 Aug	20.06 23.72	1.29	2.46 2.78	0.11	0.31 0.35	0.01	0.02 0.02	0	0.001 0.008	0.001
12 Sept	3.73 3.48	0.09	1.66 1.56	0.04	0.13 0.14	0.004	0.02 0.01	0.004	0.002 0.006	0.001

Treatment 3 (treated 1 day and 2 weeks after planting)

Planting date	Days after spraying									
	1		7		14		21		28	
	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se
11 July	5.14 11.25	2.16	1.23 2.04	0.29	0.05 0.02	0.01				
9 Aug	9.28 11.59	0.82	0.68 0.68	0	0.12 0.23	0.03	0.06 0.2	0.05	0.005 0.001	0.001
12 Sept	8.20 18.63	3.69	1.48 2.23	0.27	0.12 0.44	0.11	0.05 0.06	0.004	0.006 0.008	0.001

TABLE 2 continued

Treatment 4 (treated 1 day and 4 weeks after planting)

Planting date	Days after spraying									
	1		7		14		21		28	
	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se
9 Aug	1.76 1.99	0.01	0.45 0.15	0.11	0.05 0.18	0.05	0.01 0.01	0	0.003 0.002	0.0004
12 Sept	3.42 5.35	0.68	1.75 3.30	0.55	0.31 0.53	0.08	0.02 0.04	0.001	0.007 0.02	0.005

Treatment 5 (treated 1 day and 6 weeks after planting)

Planting date	Days after spraying									
	1		7		14		21		28	
	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se
9 Aug	1.80 2.09	0.1	0.37 0.32	0.02	0.61 0.58	0.01	0.02 0.04	0.01	0.008 0.004	0.001
12 Sept	1.54 1.81	0.1	0.36 0.34	0.01	0.03 0.04	0.004	0.01 0.01	0	0.01 0.004	0.002

Experiment C. 90116

The spring cabbage crop treated with the recommended dose of disulfoton FE.10 at sowing time in early August 1990 remained aphid-free until the final assessment in February 1991. There was no opportunity to assess the efficacies of supplementary treatments. In the log-dose studies, where aphid populations built up to a mean of 50-100 aphids/plant by late October, the treated plants remained aphid-free at all dose levels.

Disulfoton residues in whole plant samples were determined and are shown in Table 3.

TABLE 3: Residues of disulfoton in spring cabbage sampled in February and March

Experiment C. 90116

SPRING CABBAGE

cultivar: Myatts Offenham Campacta
sown: 6 August, 38 cm rows, thinned to 20 cm spacing
insecticide: disulfoton FE.10 at sowing, 56.3 g product/100m row
irrigation: 7, 9, 14 August; 11 September

CROP REMAINED APHID-FREE THROUGHOUT WINTER

Residues

Determined (after oxidation) as disulfoton oxygen analogue sulphone ($DOASO_2$)

Sampled	Replicate	$DOASO_2$, mg/kg
19.2.91	A	0.010
	B	0.010
	C	< 0.002
	mean	0.006
20.3.91	A	0.002
	B	0.005
	mean	0.003
Untreated (both dates)		< 0.002

Experiment D. 91032

Changes in concentrations of demeton-S-methyl residues in lettuce following application during April-August 1991 are shown in Table 4 and Figures 12-25. Following a single application 24 h after planting (Treatment 2, Figure 12), initial residue concentrations ranged from 2- 50 mg/kg: these initial residues were largest in the early July treatment and were smallest in the plants treated in June. Residue concentrations declined at a similar rate in all crops and, in all except the April planting, were < 0.5 mg/kg after 14 days. After 21 days, concentrations ranged from < 0.01 mg/kg (June planting) to 0.1 mg/kg (both July plantings). A similar pattern was evident in Treatment 3 (Figure 13), with residue concentrations in all except the April planting < 0.5 mg/kg at 7 days after treatment. The slow decline in the April planting resulted in a mean residue concentration slightly greater than the MRL after 21 days.

Comparison of all treatments in the April planting (Figure 14) showed a similarly large residue in the plants treated after 6 weeks (Treatment 5). This late treatment also led to excessive concentrations in lettuce planted in May (Figure 15), whereas the 2- and 4-week applications left residues of only 0.02-0.03 mg/kg. In the June planting (Figure 16), consistent differences between treatments which were established at application were maintained until harvest, with residues always largest in the plants treated after 4 weeks. In the early July treatment (Figure 17), differences were smaller and inconsistent although residue levels in all treatments were < 0.5 mg/kg after 21 days. In the late July planting (Figure 18) residues were again largest in plants from Treatment 5, remaining marginally above 0.5 mg/kg after 21 days. In the August planting (Figure 19) Treatments 2 and 3 were the only practically realistic applications and residues declined rapidly to < 0.5 mg/kg within 7 days. Proportional rates of residue loss, expressed as % of initial dose, are shown in Figures 20-25. With the occasional exception of one or two treatments, rates of loss were similar in all except the April planting. In most cases, 80-90% of the initially-measured deposit had been lost within 7 days of treatment. In contrast, the earliest treatment (Treatment 2) in the April sowing (Figure 20) still retained 60% of its initial deposit after 1 week.

TABLE 4: Demeton-S-methyl residues (mg/kg ± se) in lettuce following applications to six plantings in 1991

Treatment 2 (treated 1 day after planting)

Planting date	Days after spraying									
	1		7		14		21		28	
	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se
26 April	19.44 12.42	2.48	3.04 8.06	1.78	0.39 0.91	0.18	0.05 0.02	0.01	2.18 0.69	0.53
14 May	0.03 0.04	0.004	0.08 0.08	0	1.99 1.58	0.15	0.29 0.08	0.07	0.02 0.02	0
10 June	1.45 3.29	0.68	0.18 0.11	0.03	0.03 0.01	0.007	0.01 0.004	0.002	0.003 0.002	0.0004
1 July	30.29 80.39	17.89	3.11 1.74	0.48	0.30 0.38	0.028	0.08 0.10	0.007	0.01 0.01	0
29 July	4.12 12.46	2.95	0.25 1.75	0.53	0.39 0.26	0.05	0.10 0.06	0.01	-	
28 Sept	3.42 5.31	1.14	0.17 0.26	0.03	0.05 0.03	0.007	0.02 0.02	0	0.003 0.007	0.001

Treatment 3 (treated 1 day and 2 weeks after planting)

Planting date	Days after spraying									
	1		7		14		21		28	
	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se
26 April	13.41 4.60	3.12	0.31 0.34	0.01	3.45 1.83	0.57	0.63 0.51	0.04	0.09 0.02	0.03
14 May	14.90 9.42	1.94	0.38 0.47	0.03	0.04 0.05	0.004	0.01 0.02	0.004	0.003 0.01	0.003
10 June	8.99 8.95	0.014	0.16 0.56	0.14	0.07 0.06	0.004	0.03 0.01	0.007	0.003 0.01	0.003
1 July	8.42 9.38	0.34	2.39 1.91	0.17	0.07 1.75	0.59	0.01 0.01	0	0.002 0.003	0.0004
29 July	6.02 5.42	0.21	0.39 0.12	0.1	0.08 0.03	0.02	0.02 0.01	0.004	0.03 0.003	0
28 Sept	4.04 3.84	0.07	0.70 0.26	0.16	0.04 0.09	0.02	0.005 0.003	0.001	0.004 0.002	0.0007

TABLE 4 continued

Treatment 4 (treated 1 day and 4 weeks after planting)

Planting date	Days after spraying									
	1		7		14		21		28	
	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se
26 April	7.42 7.48	0.02	0.36 1.20	0.3	0.41 0.33	0.3	0.07 0.11	0.01	0.04 0.03	0.004
14 May	21.88 9.69	4.31	0.89 0.86	0.01	0.47 0.77	0.11	0.04 0.01	0.01	0.03 0.01	0.007
10 June	12.78 12.74	0.014	1.29 0.90	0.14	0.63 0.51	0.04	0.12 0.13	0.004	0.01 0.10	0.03
1 July	48.99 40.83	2.89	2.12 4.29	0.77	0.71 0.41	0.11	0.19 0.06	0.05	0.08 0.04	0.01
29 July	3.75 12.21	2.99	0.18 2.87	0.95	0.25 0.24	0.004	0.06 0.10	0.01	0.08 0.03	0.02

Treatment 5 (treated 1 day and 6 weeks after planting)

Planting date	Days after spraying									
	1		7		14		21		28	
	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se	mg/kg	± se
26 April	10.18 7.0	1.12	2.12 2.63	0.18	0.17 2.08	0.68	0.94 0.06	0.3	0.01 0.03	0.007
14 May	21.93 18.59	1.18	1.55 2.11	0.20	0.49 1.50	0.36	0.81 0.31	0.18	0.18 0.02	0.06
10 June	0 0.15	0.05	0.02 0.02	0	0 0	0				
1 July	66.24 70.10	1.37	9.61 4.59	1.78	0.11 0.45	0.10	0.01 0.01	0	0.01 0.01	0
29 July	28.17 33.29	1.81	1.53 0.85	0.24	0.68 0.31	0.13	0.51 0.56	0.02	0.38 0.20	0.06

Experiment E. 91035

The Brussels sprout crop treated with the recommended linear dose of disulfoton FE.10 at planting in early May 1991 remained aphid-free until early August (Figure 26). A supplementary foliar application of disulfoton P.10 granules applied in early August was more effective than a demeton-S-methyl treatment applied in a volume equivalent to 600 l water/ha. Dry soil conditions limited the period of effectiveness of both insecticide treatments and they were re-applied in early September. Demeton-S-methyl and disulfoton P.10 remained effective for a further 1 and 3 weeks respectively.

Residues of both insecticides in mature sprout buttons sampled in late August and late September are shown in Table 5. Each result represents the mean of a single analysis of duplicate samples. On both sampling occasions, residues of disulfoton were at, or little more than, the limit of detection and were well below the MRL of 0.5 mg/kg, despite the fact that samples were taken only 22 and 27 days after the last foliar applications, well short of the stipulated minimum harvest interval of 6 weeks. The demeton-S-methyl treatment also left very small residue levels in the buttons.

TABLE 5: Residues of disulfoton and demeton-S-methyl in sprout buttons sampled in August and September

Experiment E. 91035

BRUSSELS SPROUTS

cultivar: Dolmic
planted: 8 May 1991, 75 x 60 cm spacing
insecticide: disulfoton FE.10 at planting

Treatments

Disulfoton FE.10, 105 g product/100 m row

+ disulfoton P.10
OR 7 August and 3 September (13 & 17 wks)
demeton-S-methyl (dsm)

Residues in button (mg/kg)

Sampled	no. of foliar treatments	days since last treatment	FE.10 only	FE.10 + P.10	FE.10[(a)] + dsm[(b)]	
					(a)	(b)
29 Aug	1	22	0.02	0.02	0.002	0.07
30 Sep	2	27	0.02	0.01	0.005	0.02

(a) determined as disulfoton oxygen analogue sulphone
(b) determined as demeton-S-methyl sulphone

Experiment F. 91037

The cauliflower crop treated with the recommended dose of disulfoton FE.10 at transplanting in mid-May remained aphid-free until maturity in early August. There was no opportunity to assess the efficacies of supplementary treatments. Residues of disulfoton in the mature plants are shown in Table 6. Residue concentrations in plants harvested in late July, 10 weeks after treatment, were substantially smaller than the MRL of 0.5 mg/kg and, after a further 2 weeks, were scarcely detectable.

TABLE 6: Residues of disulfoton in cauliflowers harvested 10 and 12 weeks after planting

Experiment F. 91037

CAULIFLOWER

cultivar: White Rock
planted: 15 May 1991, 55 x 50 cm spacing
insecticide: disulfoton FE.10 at planting

Treatments

Disulfoton FE.10, 105 g product/100 m row

Residues in mature crop

Sampled	weeks after treatment	residues[(a)]	
		mg/kg	µg/plant
23 July	10	0.014	7.9
6 August	12	0.005	3.9

[(a)] determined as disulfoton oxygen analogue sulphone

Experiment G. 91096

Cabbage aphid populations began to establish on the previously-untreated sprouts in mid-July and the first demeton-S-methyl spray was applied on 15 July. On this occasion, the smallest application volume of 100 l water/ha was less effective than the higher volumes. Subsequent applications in August and September failed to reveal any consistent or significant differences in the proportions of undamaged plants in the different treatments (Figure 27). Although the mean levels of infestation were correlated indirectly with application volume during much of August (Figure 28), the differences diminished subsequently and none of the treatments produced aphid-free sprout buttons from September onwards.

Residues in sprout buttons sampled after 2 and 4 applications are shown in Table 7. Samples taken 22 days after the second of two applications (the required minimum harvest intervals for demeton-S-methyl is 21 days) were only 0.03 - 0.05 mg/kg. In September, samples were taken only 13 days after the last of 4 applications in an attempt to establish whether there were significant differences in residue levels between the different treatments. Although residues were relatively large, ranging from 0.10 - 0.22 mg/kg, they were still well below the MRL. There was no evidence of any consistent change in residue levels with increasing dilution.

TABLE 7: Residues of demeton-S-methyl in sprout buttons sampled in August and September

Experiment G. 91096

BRUSSELS SPROUTS

cultivar: Dolmic
planted: 7 May 1991, 75 x 60 cm spacing
insecticide: demeton-S-methyl in different volumes of water

Residues in buttons (mg/kg)

Sampled	Spray treatments	Days after last treatment	mg/kg
29 August	2 x 100 l/ha	22	0.03
	2 x 300 l/ha	22	0.05
	2 x 600 l/ha	22	0.03
	2 x 1200 l/ha	22	0.03
30 September	3 x 100 l/ha +1 x 300 l/ha	13	0.10
	3 x 300 l/ha +1 x 600 l/ha	13	0.22
	3 x 600 l/ha +1 x 1200 l/ha	13	0.12
	3 x 1200 l/ha +1 x 1800 l/ha	13	0.19

Experiment H. 92052

Aphid monitoring

Aphid infestations on the Brussels sprouts treated with band and side-placement applications of disulfoton were monitored from late August until early November. Changes in the proportion of infested sprout buttons are shown in Figures 29-34, the mean numbers of aphids per button are shown in Figures 35 and 36 and the proportions of clean plants in Figures 37 and 38. The mean data from the four replicate plots are presented also in Table 8, together with least significant differences at the 95% confidence level.

The sub-surface in-row band of disulfoton FE.10 applied at planting time maintained a moderate level of protection throughout the monitoring periods. By late August, 10% of the sprout buttons on these plants contained at least 1 aphid and this level of infestation changed little during the following 6-8 weeks, rising to 15% infestation by early November. The data from the band treatment (Treatment 1) are shown in each of the Figures 29-38.

The proportions of infested buttons in the plants treated with the shallower placement (10 x 10 cm and 10 x 15 cm) are shown in Figure 29. The corresponding results for the deeper placements (15 x 15 and 15 x 20 cm) are shown in Figure 30. With both placements, the greatest reductions in infestations were achieved with the treatments applied 5 weeks after transplanting (Treatments 6 and 7). Differences between the treatment dates are shown also in Figures 31-34, with the performance of both placements compared, for each date, with that of the sub-surface band. Figure 31 indicates that the side-placements at planting time were less effective than the sub-surface band: by mid-September, 15-23% of the buttons from the former treatment were infested and infestations remained higher than in the band treatment until the final assessment in early November. The shallower placement (Treatment 2) was generally more effective than the deeper placement (Treatment 3).

The performances of the side-placements relative to those of the sub-surface band improved subsequently. When applied 3 weeks after planting (Figure 32), the side-placement treatments performed similarly to the band treatment, with no significant differences (P = 0.05) in the proportions of infested buttons in the different treatments on most of the sampling dates between late August and early November. However, the greatest improvement in performance was achieved by the deep side-placements applied 5 weeks after planting (Figure 33), with the shallower placement again performing better than the deeper placement. By the end of September, buttons from plants treated with the shallower placement were aphid-free and were reinfested subsequently only slowly. By early November, there were no significant differences (P = 0.05) between the 5-week side-placements and the band application. The performances of the final deep side-placements, made 7 weeks after planting, did not differ significantly (P = 0.05) from that of the planting time, sub-surface band (Figure 34). Furthermore, these 7-week applications were achieved only with some

difficulty, as the larger plants were often struck by the framework of the applicator attachment. Although relatively large proportions of buttons were shown to be infested with cabbage aphid, levels of infestations were relatively small. The mean numbers of aphids per button are shown in Figure 35 (shallow placement, Treatments 2, 4, 6 and 8, plus Treatment 1) and Figure 36 (deeper placement, Treatments 3, 5, 7 and 9, plus Treatment 1). Even the least effective treatments never contained as many as 2 aphids per plant and the most effective treatments contained only 0-0.5 (mean values) aphids per plant. Figures 37 and 38 show the results in terms of the proportions of aphid-free plants relative to the interval after each application date. Although all of the treatments provided a high degree of protection, only the 5-week applications achieved 100% control at both placement depths.

Residues

Residues in the youngest unfurled leaves of plants were analysed in samples taken from 24 June (Treatments 1-7) or 9 July (Treatments 8 and 9) until 21 September. The residues comprised only disulfoton sulphone (DSO_2) and/or disulfoton oxygen analogue sulphone ($DOASO_2$) and results for each replicate sample are shown in Table 9. The mean data are shown also in Figures 39-42 with residues depicted on a log-scale to show differences in the very small concentrations present in most samples. There were no consistent significant ($P = 0.05$) differences in the residue concentrations either between treatment dates or, on each treatment date, between the 2 placement depths. Residue concentrations in mature sprout buttons sampled in September are shown in Table 10. These concentrations were scarcely detectable and, in buttons from all treatments, were well below a reporting limit (generally 0.01 mg/kg for disulfoton). Further samples were taken until December and residues were always <0.01 mg/kg.

It should be noted that, from early July onwards, insecticide availability and uptake was likely to have been near-optimal. Total rainfall during the period from late June to the end of October was 324 mm, with 0.1 mm or more being recorded on 71 of the 125 days and 10 mm or more on 14 days (Figure 45).

TABLE 8: Mean % infested plants, ± standard errors and least significant differences at the 95% confidence level in sprouts sampled from late August until early November

Experiment H. 92052

Date sampled	Treatment no.	Mean % infested plants	± se	LSD (P = 0.05)
27 August	1	10.3	3.35	9.3
	2	7.2	2.95	8.2
	3	10.1	2.10	5.8
	4	7.1	1.20	3.3
	5	9.7	1.90	5.3
	6	2.9	1.40	3.9
	7	12.7	4.20	11.7
	8	10.8	4.95	13.7
	9	10.2	5.55	15.4
15 September	1	11.5	5.55	15.4
	2	20.9	6.55	18.2
	3	16.0	1.40	3.9
	4	9.3	1.05	2.9
	5	10.3	1.70	4.7
	6	6.9	3.95	11.0
	7	6.2	1.50	4.2
	8	14.3	3.50	9.7
	9	12.0	2.85	7.9
29 September	1	9.9	2.50	6.9
	2	12.4	8.40	23.3
	3	19.5	2.15	6.0
	4	7.5	4.35	12.1
	5	10.1	3.00	8.3
	6	0	0	0
	7	1.9	0.65	1.8
	8	11.6	3.65	10.1
	9	4.8	1.05	2.9
15 October	1	9.0	3.05	8.5
	2	16.9	3.25	9.0
	3	22.4	4.85	13.5
	4	8.8	3.75	10.4
	5	9.7	3.80	10.6
	6	0.6	0.65	1.8
	7	7.6	2.45	6.8
	8	8.1	0.65	1.8
	9	9.4	2.75	7.6
3 November	1	15.0	4.85	13.5
	2	15.6	6.00	16.7
	3	13.8	6.60	18.3
	4	13.1	6.95	19.3
	5	18.8	4.60	12.8
	6	9.4	1.90	5.3
	7	12.5	3.05	8.5
	8	23.1	4.70	13.1
	9	8.1	2.75	7.6

TABLE 9: Disulfoton residues (mg/kg) in upper leaves of Brussels sprout plants following sub-surface and deep side-placement applications of disulfoton FE.10

Experiment H. 92052

Treatment 1. Sub-surface band at planting

Sampling date	Days after application	Repl.	mg/kg			
			$DOASO_2$	DSO_2	Total	Mean
24/6/92	41	A	0.353	0.006	0.359	0.38
		B	0.283	0.115	0.398	
9/7/92	56	A	0.076	nd	0.076	0.10
		B	0.116	nd	0.116	
24/7/92	71	A	0.299	nd	0.299	0.36
		B	0.420	0.006	0.425	
6/8/92	84	A	0.008	nd	0.008	0.01
		B	0.005	nd	0.005	
20/8/92	98	A	0.059	nd	0.059	0.07
		B	0.075	nd	0.076	
7/9/92	116	A	0.018	nd	0.018	0.05
		B	0.081	nd	0.081	
21/9/92	140	A	0.035	nd	0.035	0.03
		B	0.033	nd	0.033	

Treatment 2. Deep side-placement, 10 x 10 cm, 0 weeks

Sampling date	Days after application	Repl.	mg/kg			
			$DOASO_2$	DSO_2	Total	Mean
24/6/92	41	A	0.795	0.205	0.999	0.75
		B	0.461	0.030	0.491	
9/7/92	56	A	0.056	nd	0.056	0.06
		B	0.059	nd	0.059	
24/7/92	71	A	0.170	nd	0.170	0.16
		B	0.141	nd	0.141	
6/8/92	84	A	0.015	nd	0.015	0.01
		B	0.006	nd	0.006	
20/8/92	98	A	0.109	nd	0.109	0.10
		B	0.086	nd	0.086	
7/9/92	116	A	0.022	nd	0.022	0.04
		B	0.052	nd	0.052	
21/9/92	140	A	0.024	nd	0.024	0.03
		B	0.030	nd	0.030	

TABLE 9 continued

Treatment 3. Deep side-placement, 15 x 15 cm, 0 weeks

Sampling date	Days after application	Repl.	mg/kg			
			$DOASO_2$	DSO_2	Total	Mean
24/6/92	41	A	0.526	0.144	0.670	0.95
		B	0.897	0.330	1.227	
9/7/92	56	A	0.054	nd	0.054	0.06
		B	0.068	nd	0.068	
24/7/92	71	A	0.050	nd	0.050	0.06
		B	0.080	nd	0.080	
6/8/92	84	A	0.029	nd	0.029	0.02
		B	0.003	nd	0.003	
20/8/92	98	A	0.095	nd	0.095	0.06
		B	0.016	nd	0.016	
7/9/92	116	A	0.005	nd	0.005	0.01
		B	0.006	nd	0.006	
21/9/92	140	A	0.009	nd	0.009	0.02
		B	0.022	nd	0.022	

Treatment 4. Deep side-placement, 10 x 10 cm, 3 weeks

Sampling date	Days after application	Repl.	mg/kg			
			$DOASO_2$	DSO_2	Total	Mean
24/6/92	21	A	0.706	0.415	1.121	0.60
		B	0.082	0.002	0.084	
9/7/92	36	A	0.159	0.007	0.166	0.13
		B	0.092	nd	0.092	
24/7/92	51	A	0.408	0.004	0.412	0.31
		B	0.217	0.001	0.218	
6/8/92	64	A	0.053	nd	0.053	0.05
		B	0.055	nd	0.055	
20/8/92	78	A	0.059	nd	0.059	0.05
		B	0.037	nd	0.037	
7/9/92	96	A	0.004	nd	0.004	0.00
		B	nd	nd	nd	
21/9/92	110	A	0.023	nd	0.023	0.02
		B	0.025	nd	0.025	

TABLE 9 continued

Treatment 5. Deep side-placement, 15 x 15 cm, 3 weeks

Sampling date	Days after application	Repl.	mg/kg			
			$DOASO_2$	DSO_2	Total	Mean
24/6/92	21	A	1.169	1.040	2.209	1.81
		B	0.802	0.609	1.411	
9/7/92	36	A	0.422	0.037	0.459	0.35
		B	0.221	0.013	0.234	
24/7/92	51	A	0.205	0.003	0.208	0.25
		B	0.285	0.001	0.286	
6/8/92	64	A	0.211	nd	0.211	0.22
		B	0.225	nd	0.225	
20/8/92	78	A	0.044	nd	0.044	0.04
		B	0.034	nd	0.034	
7/9/92	96	A	0.001	nd	0.001	0.02
		B	0.038	nd	0.038	
21/9/92	110	A	0.011	nd	0.011	0.04
		B	0.059	nd	0.059	

Treatment 6. Deep side-placement, 10 x 10 cm, 5 weeks

Sampling date	Days after application	Repl.	mg/kg			
			$DOASO_2$	DSO_2	Total	Mean
24/6/92	6	A	0.012	0.001	0.013	0.02
		B	0.020	0.001	0.021	
9/7/92	21	A	0.067	0.001	0.068	0.10
		B	0.138	nd	0.138	
24/7/92	36	A	0.582	0.010	0.592	0.45
		B	0.301	0.010	0.312	
6/8/92	49	A	0.068	nd	0.068	0.07
		B	0.064	nd	0.064	
20/8/92	63	A	0.035	nd	0.035	0.03
		B	0.030	nd	0.030	
7/9/92	81	A	0.021	nd	0.021	0.02
		B	0.022	nd	0.022	
21/9/92	95	A	0.035	nd	0.035	0.02
		B	0.014	nd	0.014	

TABLE 9 continued

Treatment 7. Deep side-placement, 15 x 15 cm, 5 weeks

Sampling date	Days after application	Repl.	mg/kg			
			$DOASO_2$	DSO_2	Total	Mean
9/7/92	21	A	0.537	0.099	0.636	0.61
		B	0.556	0.026	0.582	
24/7/92	36	A	0.471	0.022	0.493	0.32
		B	0.142	0.005	0.147	
6/8/92	49	A	0.125	nd	0.125	0.13
		B	0.137	nd	0.137	
20/8/92	53	A	0.025	nd	0.025	0.02
		B	0.018	nd	0.018	
7/9/92	81	A	0.044	nd	0.044	0.03
		B	0.010	nd	0.010	
21/9/92	95	A	0.022	nd	0.022	0.01
		B	0.005	nd	0.005	

Treatment 8. Deep side-placement, 10 x 15 cm, 7 weeks

Sampling date	Days after application	Repl.	mg/kg			
			$DOASO_2$	DSO_2	Total	Mean
9/7/92	7	A	0.003	nd	0.003	0.00
		B	0.006	nd	0.006	
24/7/92	22	A	0.245	0.002	0.247	0.34
		B	0.423	0.001	0.424	
6/8/92	35	A	0.187	nd	0.187	0.23
		B	0.277	nd	0.277	
20/8/92	49	A	0.104	nd	0.104	0.11
		B	0.108	nd	0.108	
7/9/92	67	A	0.041	nd	0.041	0.04
		B	0.033	nd	0.033	
21/9/92	81	A	0.030	nd	0.030	0.03
		B	0.020	nd	0.020	

TABLE 9 continued

Treatment 9. Deep side-placement, 15 x 20 cm, 7 weeks

Sampling date	Days after application	Repl.	mg/kg			
			$DOASO_2$	DSO_2	Total	Mean
9/7/92	7	A	0.012	nd	0.012	0.01
		B	0.008	0.004	0.012	
24/7/92	22	A	0.220	nd	0.220	0.22
		B	0.218	nd	0.218	
6/8/92	35	A	0.161	nd	0.166	0.17
		B	0.172	nd	0.172	
20/8/92	49	A	0.097	nd	0.097	0.09
		B	0.081	nd	0.081	
7/9/92	67	A	0.052	nd	0.052	0.04
		B	0.036	nd	0.036	
21/9/92	81	A	0.026	nd	0.026	0.02
		B	0.017	nd	0.017	

nd = < 0.001 mg/kg

TABLE 10: Disulfoton residues in sprout buttons

Experiment H. 92052

Samples taken 15 September 1992

Treatment	Blocks	mg/kg
1. Bow-wave before planting	A + D	0.004
	B + C	0.005
2. dsp 10 cm at planting	A + D	0.004
	B + C	0.002
3. dsp 15 cm at planting	A + D	0.001
	B + C	nd
4. dsp 10 cm at 3 weeks	A + D	0.001
	B + C	0.002
5. dsp 15 cm at 3 weeks	A + D	0.003
	B + C	0.002
6. dsp 10 cm at 5 weeks	A + D	0.003
	B + C	0.002
7. dsp 15 cm at 5 weeks	A + D	0.003
	B + C	0.002
8. dsp 15 cm at 7 weeks	A + D	0.002
	B + C	0.002
9. dsp 20 cm at 7 weeks	A + D	0.003
	B + C	0.002

dsp = deep side-placement

nd = not detected (<0.001 mg/kg)

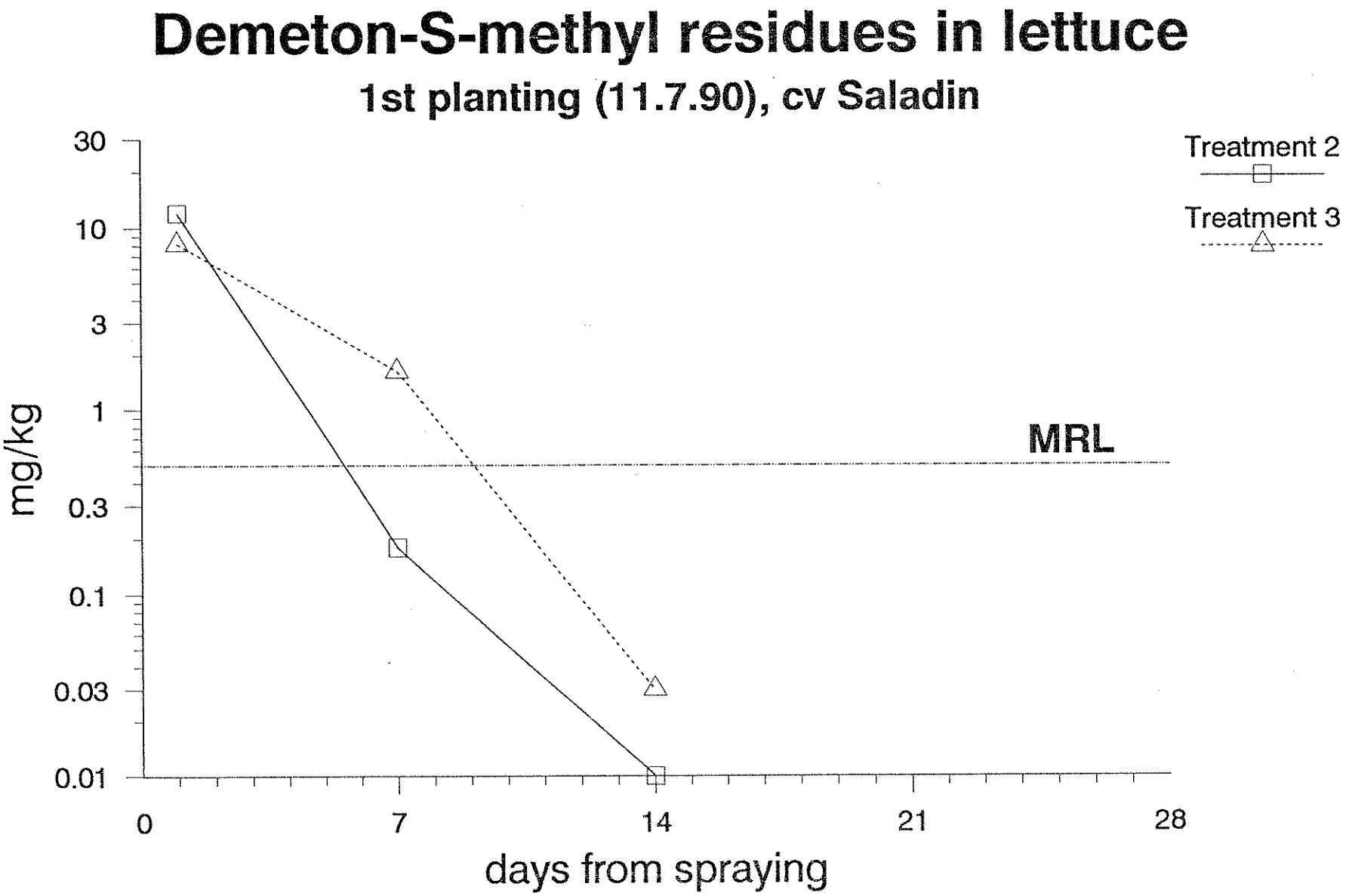

FIGURE 6: Decline of demeton-S-methyl residues in lettuce following application 1 day (Treatment 2) and 1 day and 2 weeks (Treatment 3) after planting in July

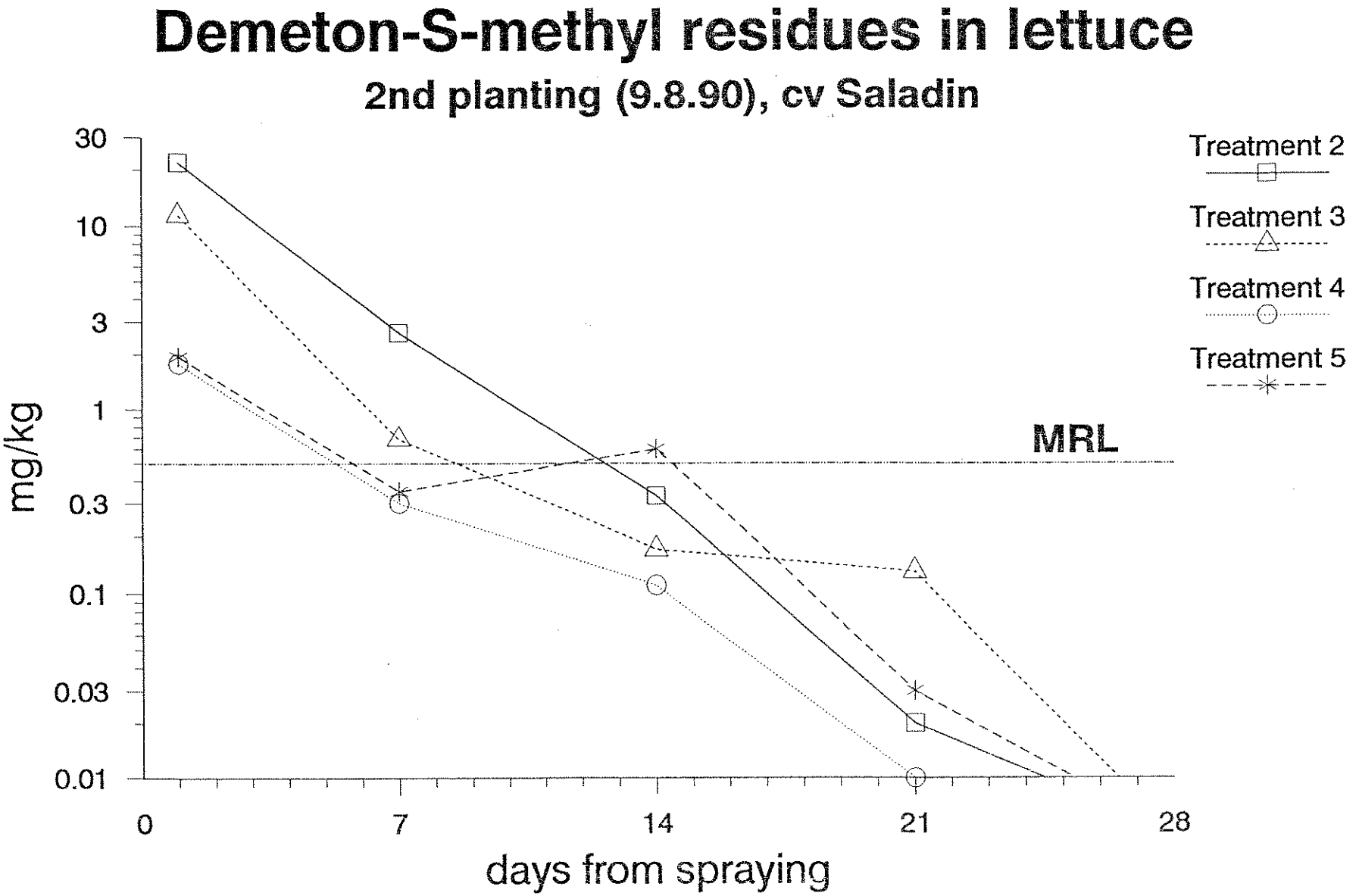

FIGURE 7: Decline of demeton-S-methyl residues in lettuce following application 1 day (Treatment 2), 1 day and 2 weeks (Treatment 3), 1 day and 4 weeks (Treatment 4) and 1 day and 6 weeks (Treatment 5) after planting in August 1990

CONCLUSIONS

Control of cabbage aphid on brassicas

The prolonged effectiveness against cabbage aphid of disulfoton and demeton-S-methyl was established.

A sub-surface band application of disulfoton FE.10 at transplanting ensured a 2-3 month period of total protection of early summer cauliflower and early-, mid- and late-season Brussels sprouts and protected autumn-sown spring cabbage for >6 months.

On Brussels sprouts, control was prolonged effectively by foliar application of either disulfoton P.10 granules or demeton-S-methyl.

Disulfoton P.10 was always the more effective, protecting the crop for 2-3 times longer than demeton-S-methyl.

Deep side-placement of disulfoton FE.10 to Brussels sprouts some weeks after transplanting enabled optimum efficacy to be achieved and maintained with greatly-reduced exposure to operators.

With all crops, residues of disulfoton or of disulfoton + demeton-S-methyl at harvest were at or little more than the limits of detection and were generally only 1-2% of the MRL.

Control of foliar aphids on lettuce

It was established that the prolonged effectiveness of demeton-S-methyl against foliar aphids on lettuce could be achieved and maintained at most times of the year without inducing unacceptable concentrations of residues in the mature crop.

Observations of the stipulated minimum harvest interval should ensure that, in all except the earliest outdoor plantings, residues do not exceed the MRL following application of demeton-S-methyl at any stage of plant growth.

Br. sprouts: cabbage aphid control
disulfoton FE-10

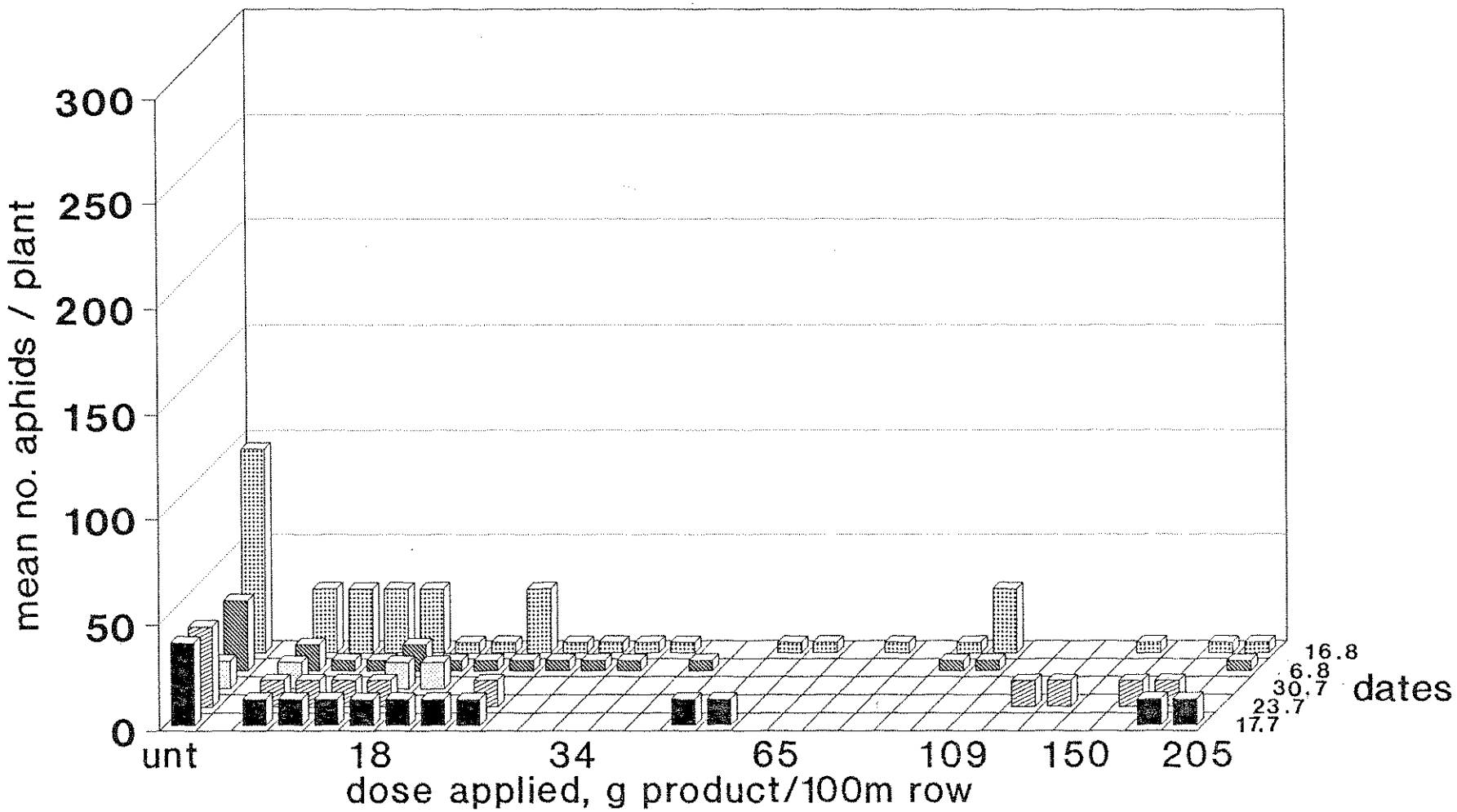

FIGURE 1: Changes in numbers of cabbage aphids on Brussels sprouts during July and August following a log-dose application of disulfoton FE.10 granules

Br. sprouts: cabbage aphid control

disulfoton FE-10

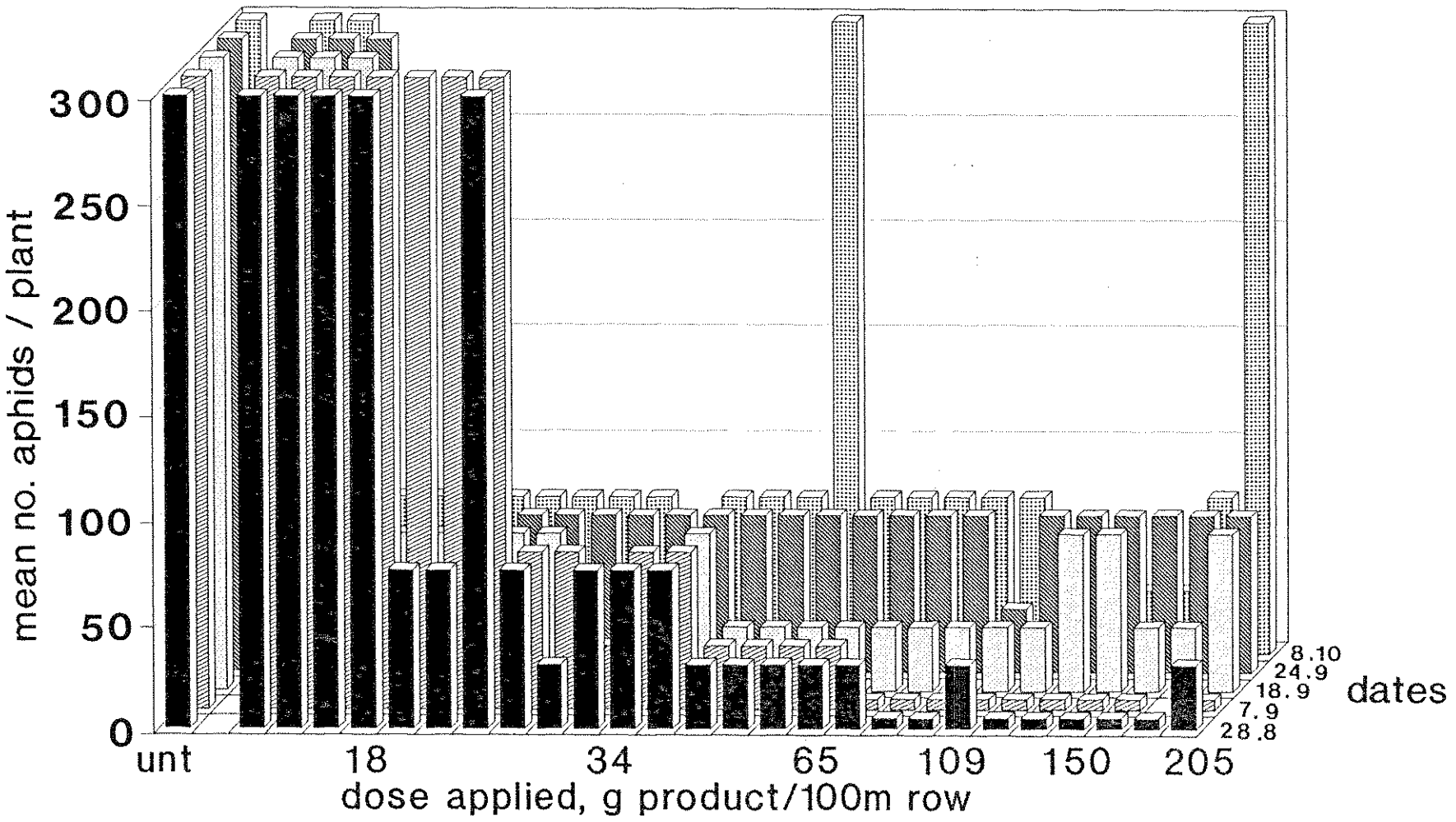

FIGURE 2: Changes in numbers of cabbage aphids on Brussels sprouts during August-October following a log-dose application of disulfoton FE.10 granules

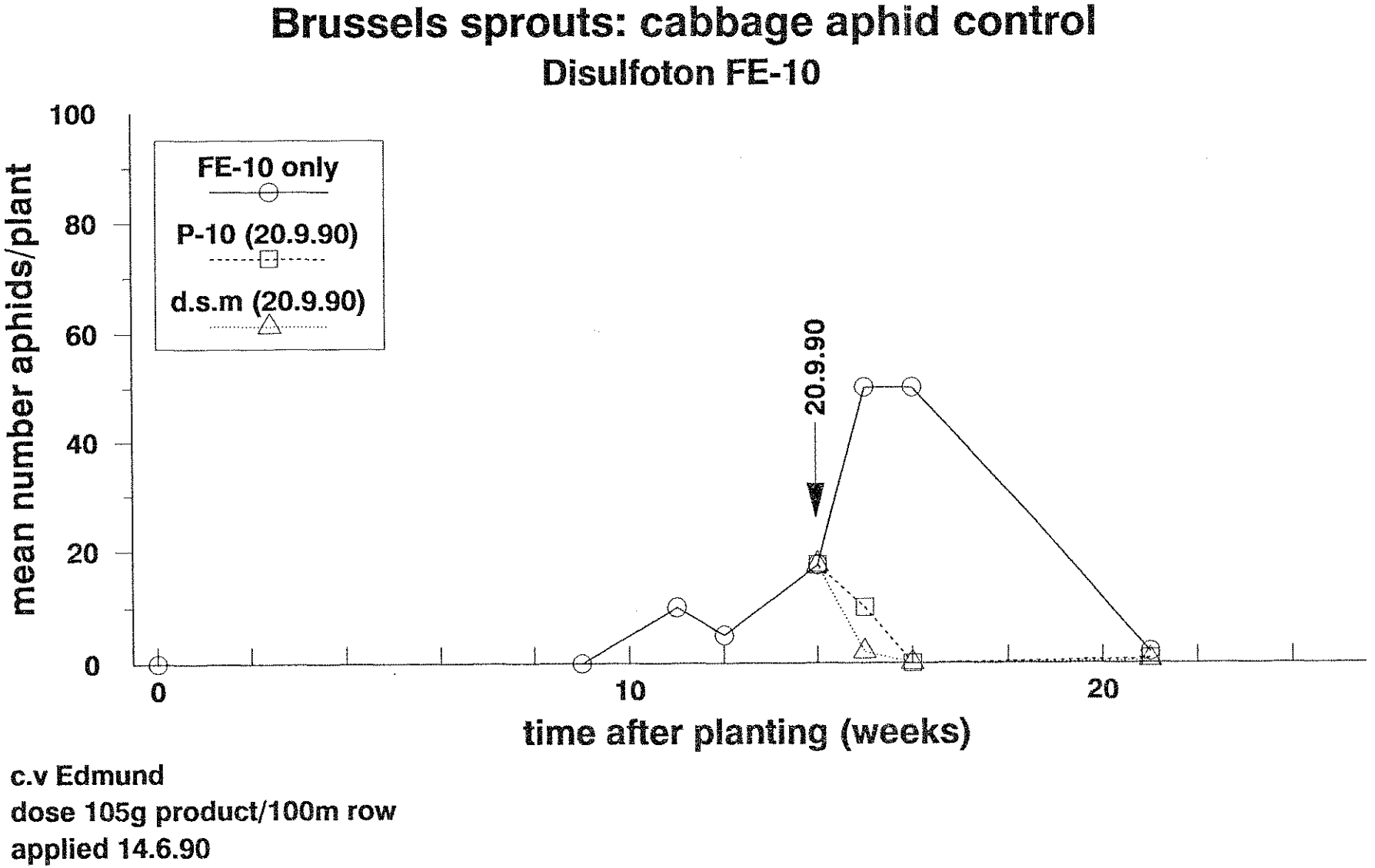

FIGURE 3: Changes in numbers of cabbage aphids on Brussels sprouts following application of the recommended dose of disulfoton FE.10 in mid-June supplemented with foliar applications of disulfoton P.10 or demeton-S-methyl in September 1990

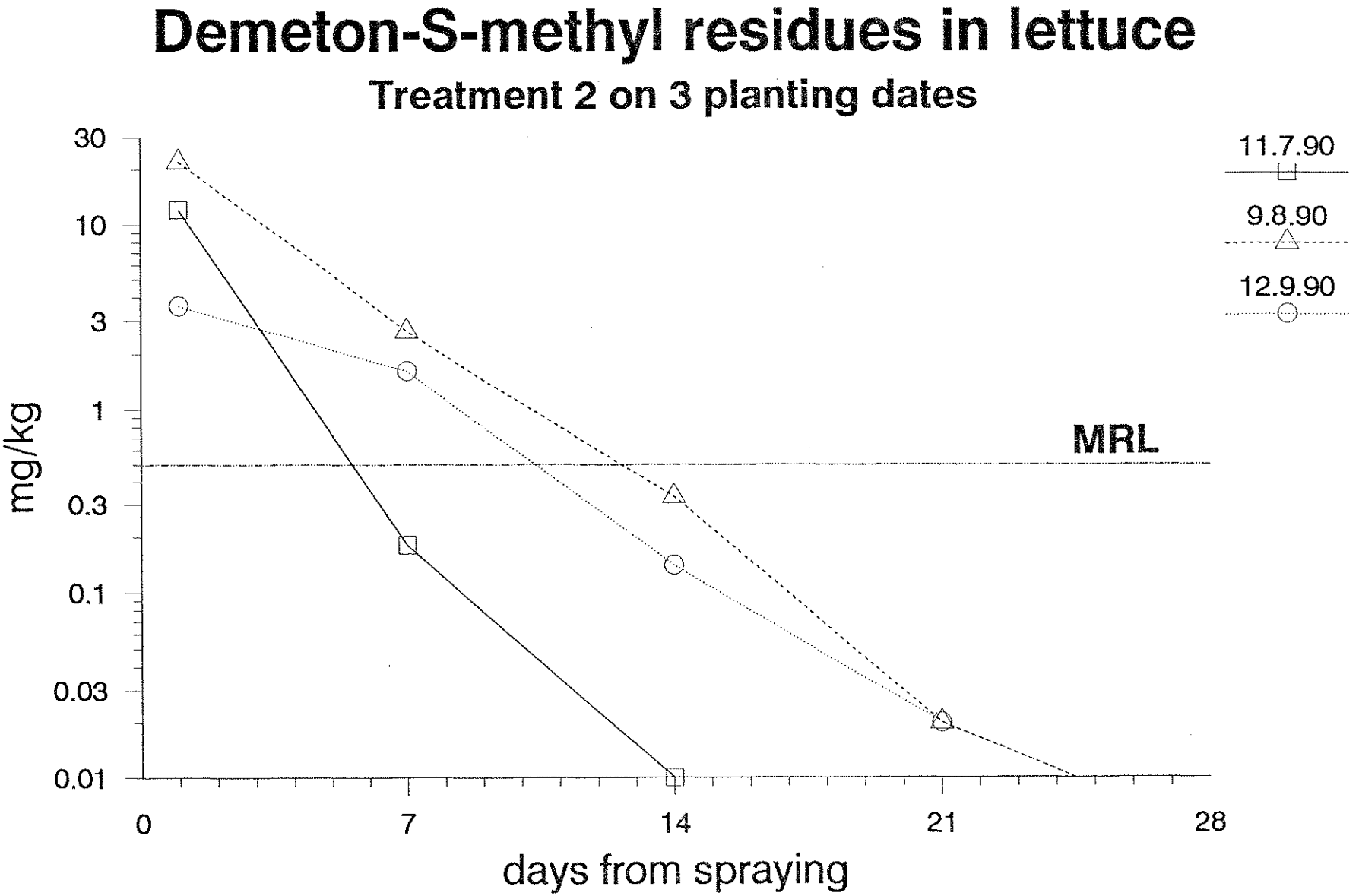

FIGURE 4: Decline of demeton-S-methyl residues in lettuce following a single application of the recommended dose 1 day after planting in July, August and September 1990

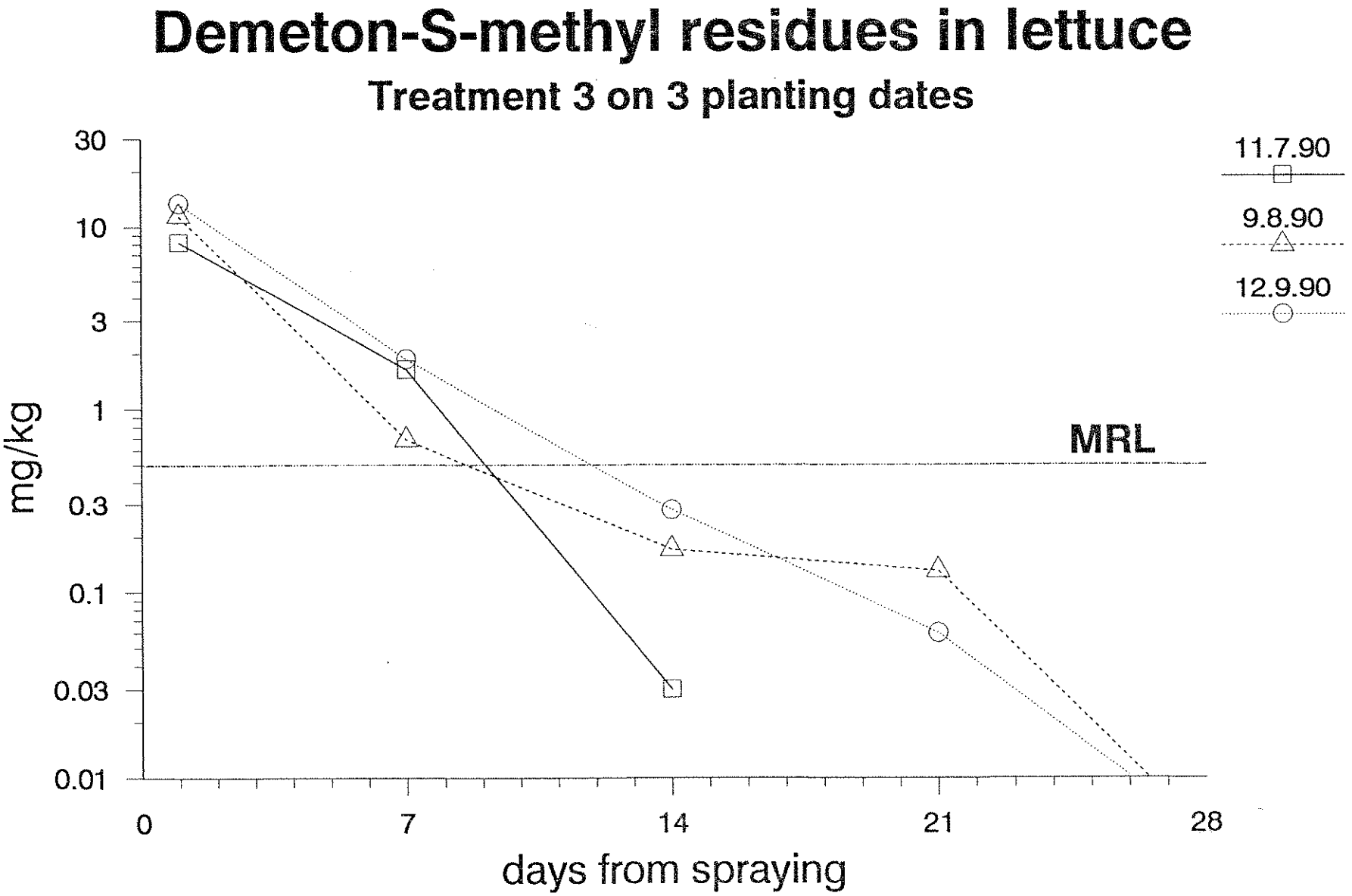

FIGURE 5: Decline of demeton-S-methyl residues in lettuce following applications 1 day and 2 weeks after planting in July, August and September 1990

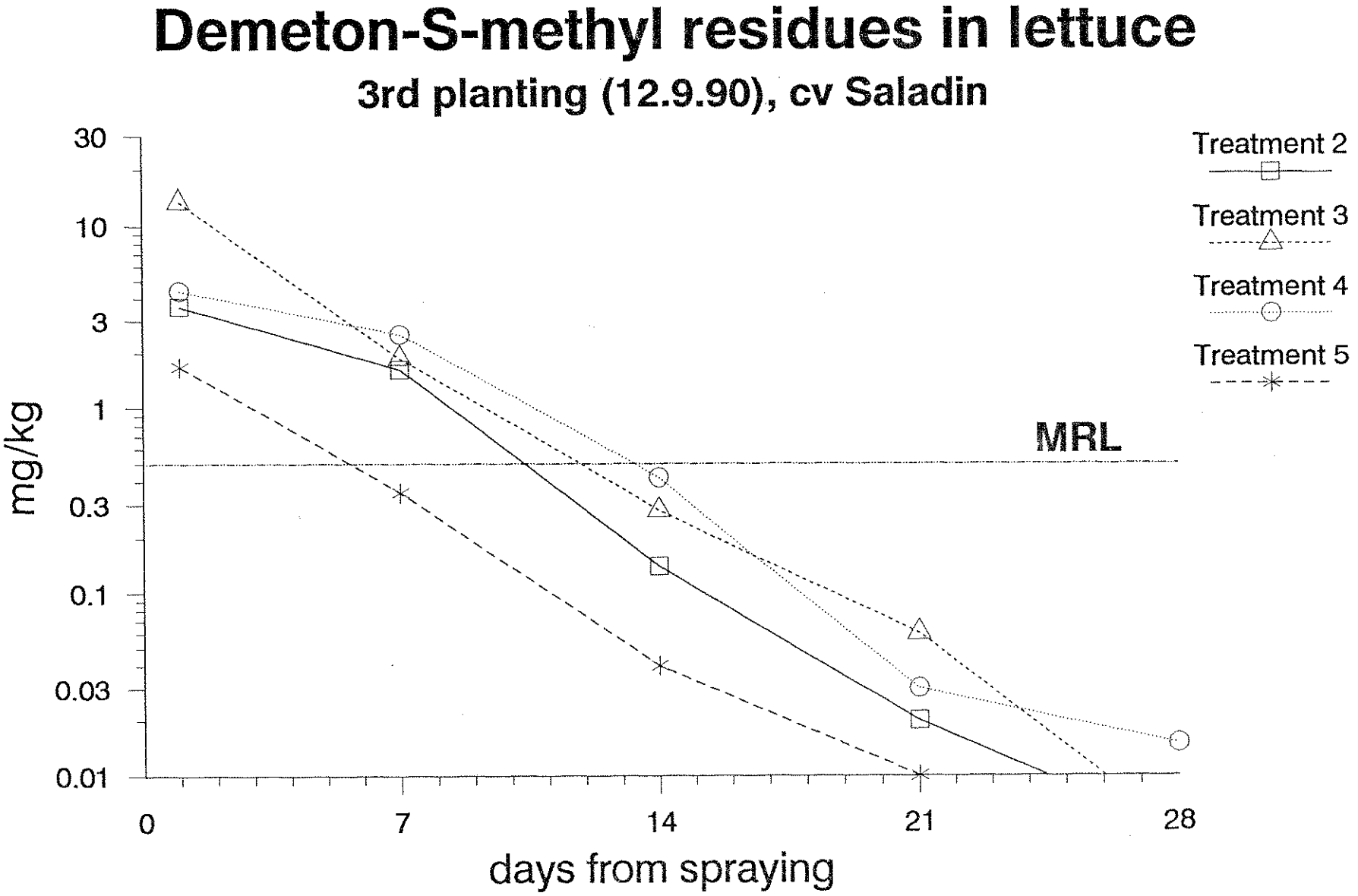

FIGURE 8: Decline of demeton-S-methyl residues in lettuce following application 1 day (Treatment 2), 1 day and 2 weeks (Treatment 3), 1 day and 4 weeks (Treatment 4) and 1 day and 6 weeks (Treatment 5) after planting in September

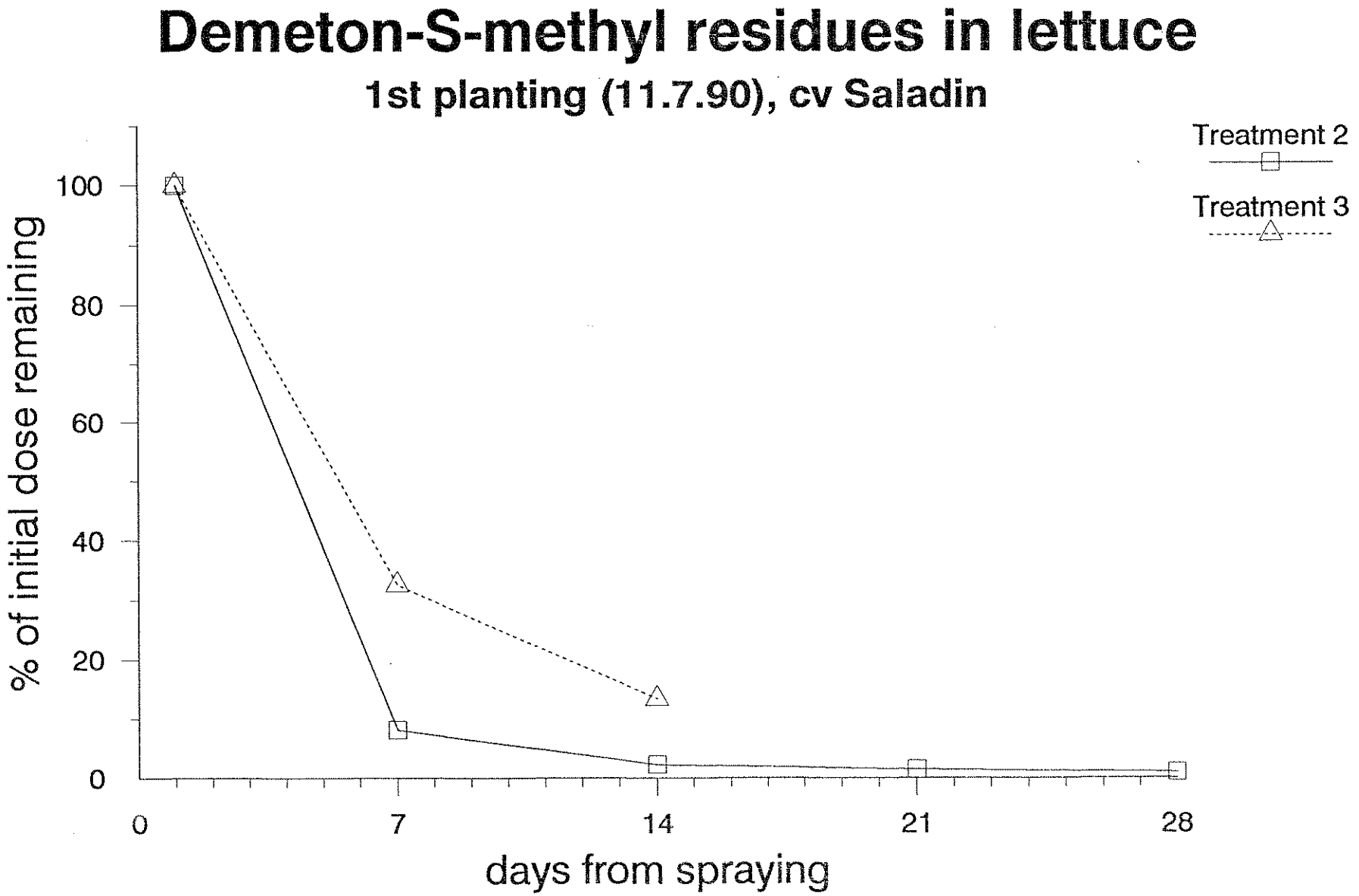

FIGURE 9: Proportional decline of demeton-S-methyl residues in lettuce following application 1 day (Treatment 2) and 1 day and 2 weeks (Treatment 3) after planting in July

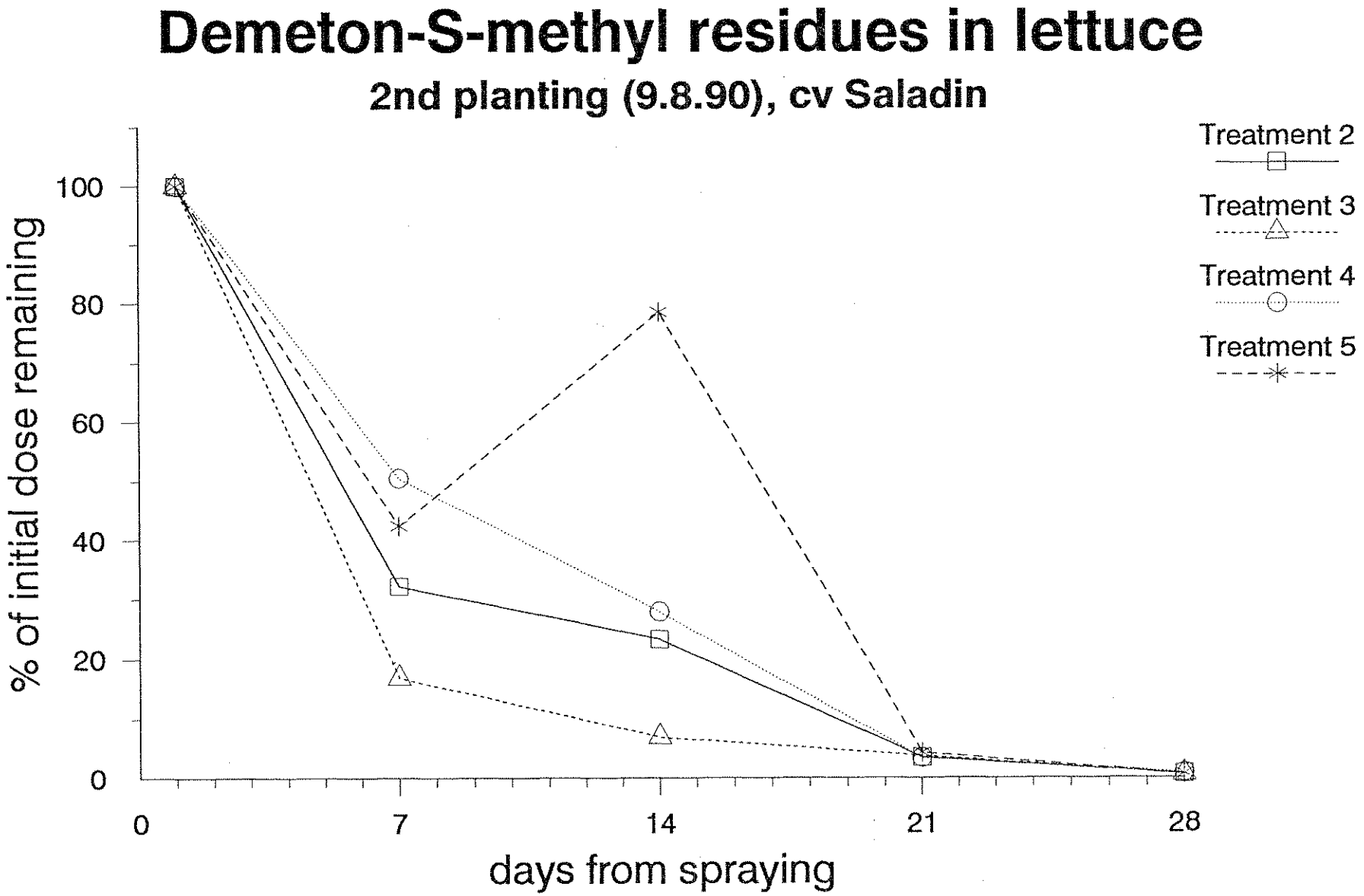

FIGURE 10: Proportional decline of demeton-S-methyl residues in lettuce following application 1 day (Treatment 2), 1 day and 2 weeks (Treatment 3), 1 day and 4 weeks (Treatment 4) and 1 day and 6 weeks (Treatment 5) after planting in August 1990

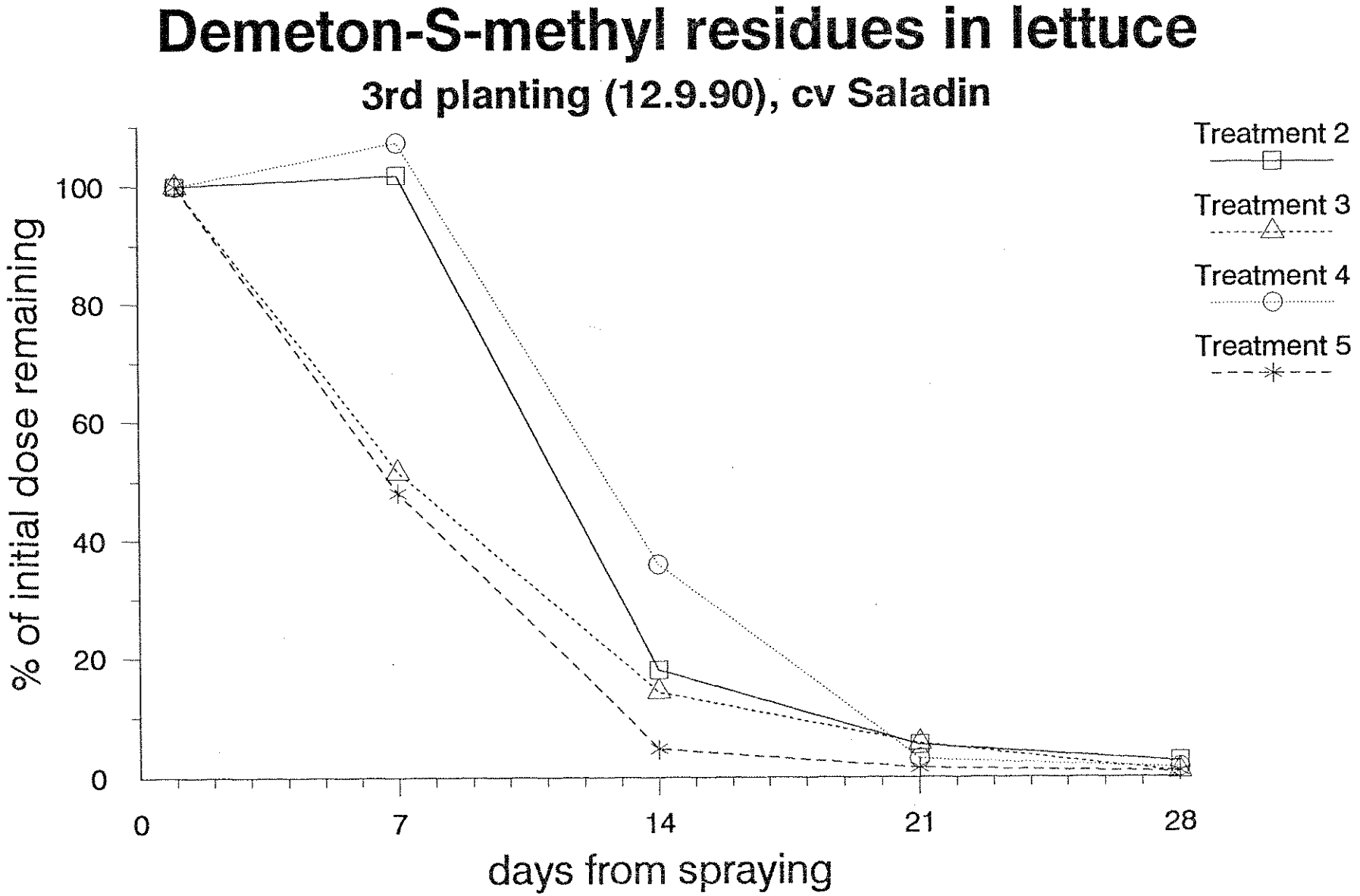

FIGURE 11: Proportional decline of demeton-S-methyl residues in lettuce following application 1 day (Treatment 2), 1 day and 2 weeks (Treatment 3), 1 day and 4 weeks (Treatment 4) and 1 day and 6 weeks (Treatment 5) after planting in September

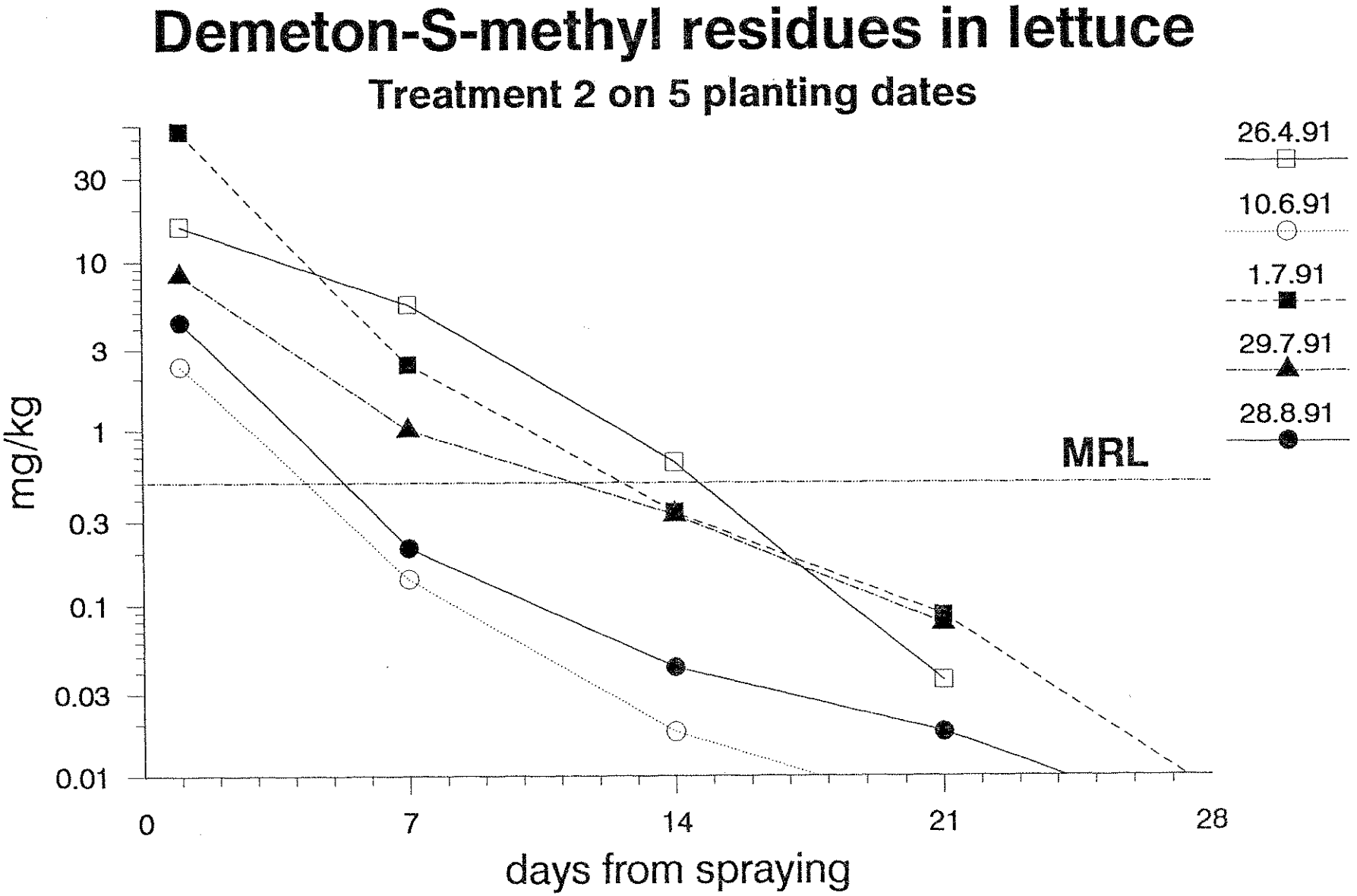

FIGURE 12: Decline of demeton-S-methyl residues in lettuce following a single application of the recommended dose 1 day after planting on 5 occasions between April and August 1991

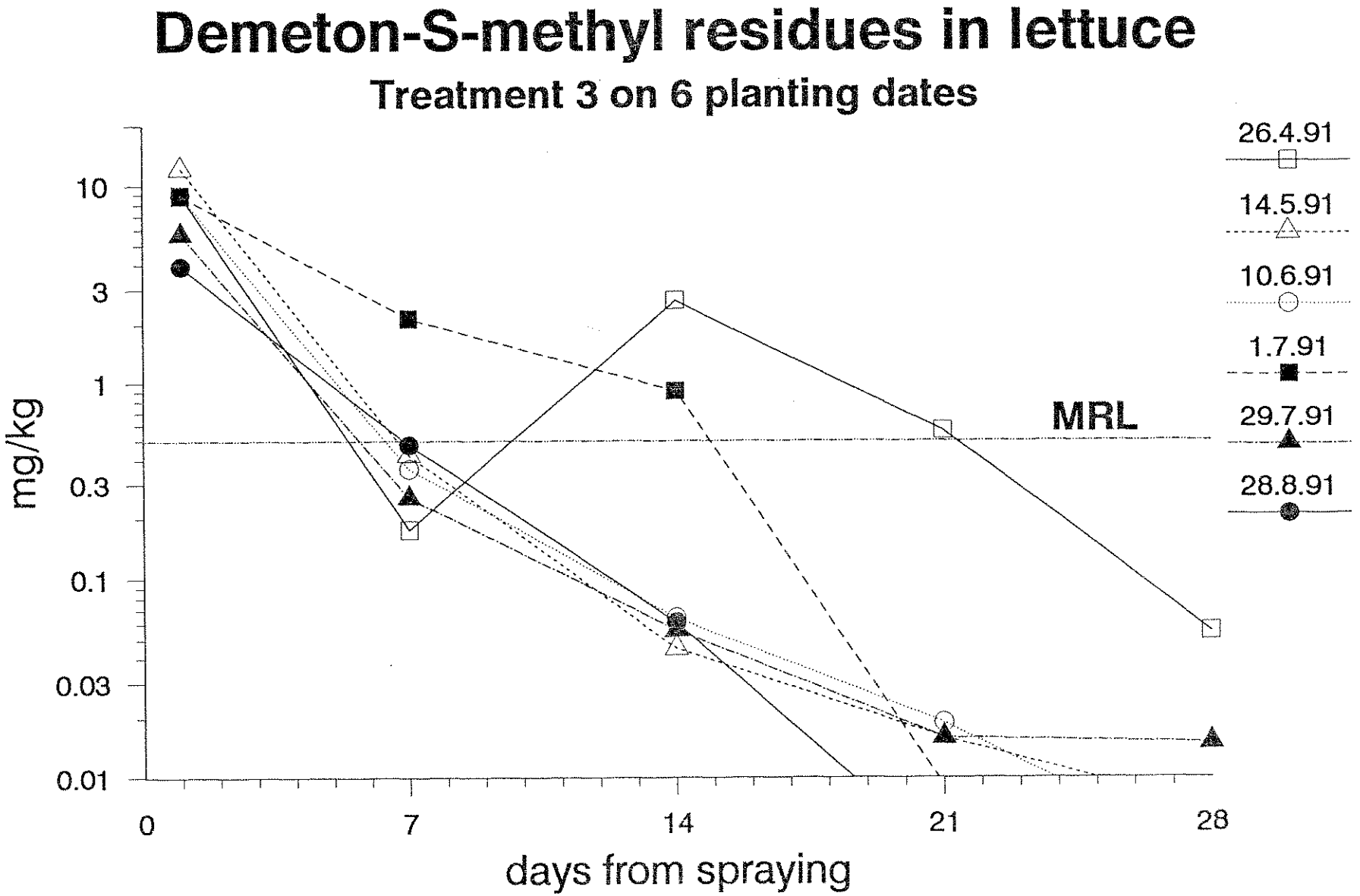

FIGURE 13: Decline of demeton-S-methyl residues in lettuce following applications 1 day and 2 weeks after planting on 6 occasions between April and August 1991

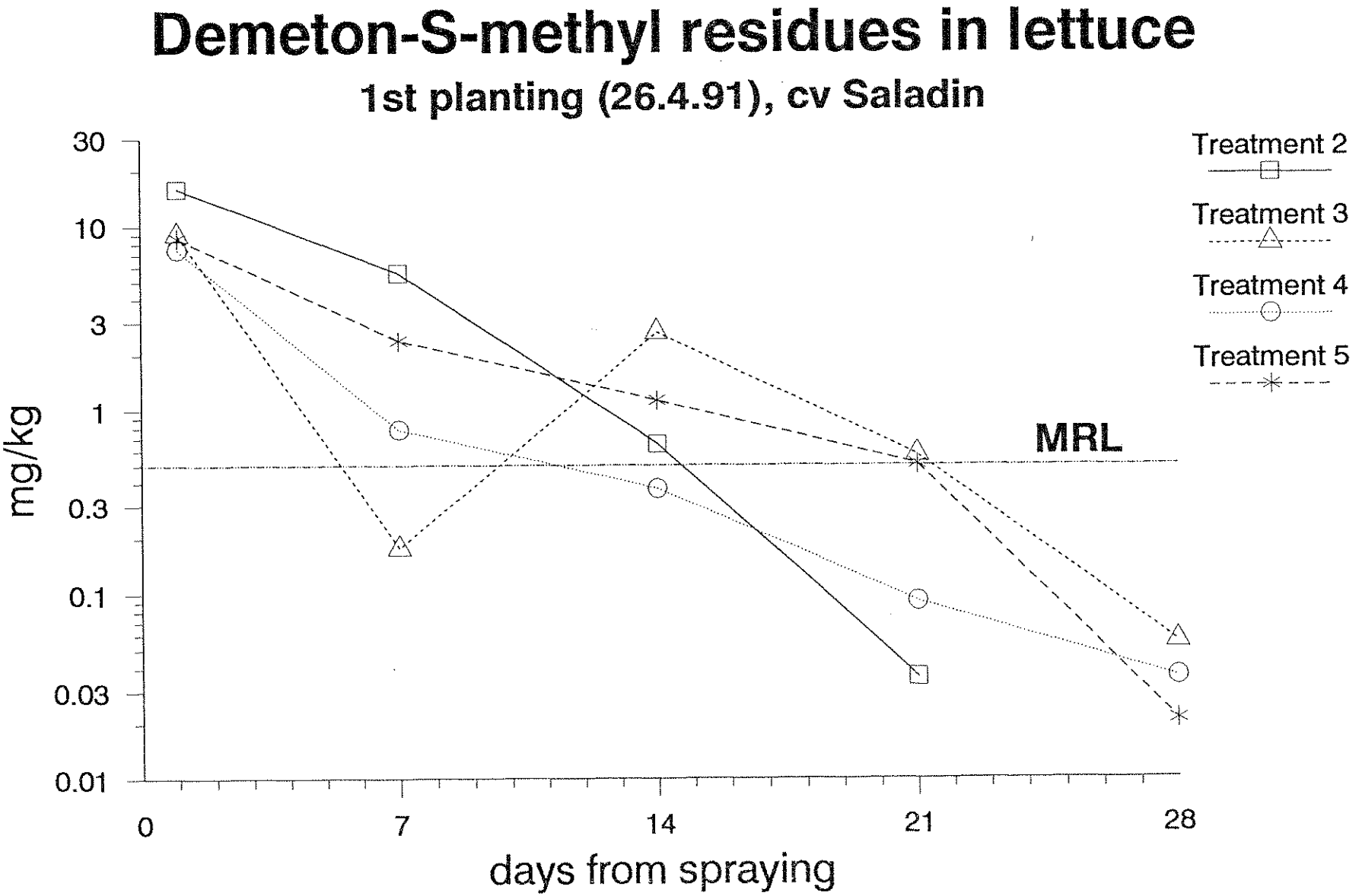

FIGURE 14: Decline of demeton-S-methyl residues in lettuce following application 1 day (Treatment 2), 1 day and 2 weeks (Treatment 3), 1 day and 4 weeks (Treatment 4) and 1 day and 6 weeks (Treatment 5) after planting in April 1991

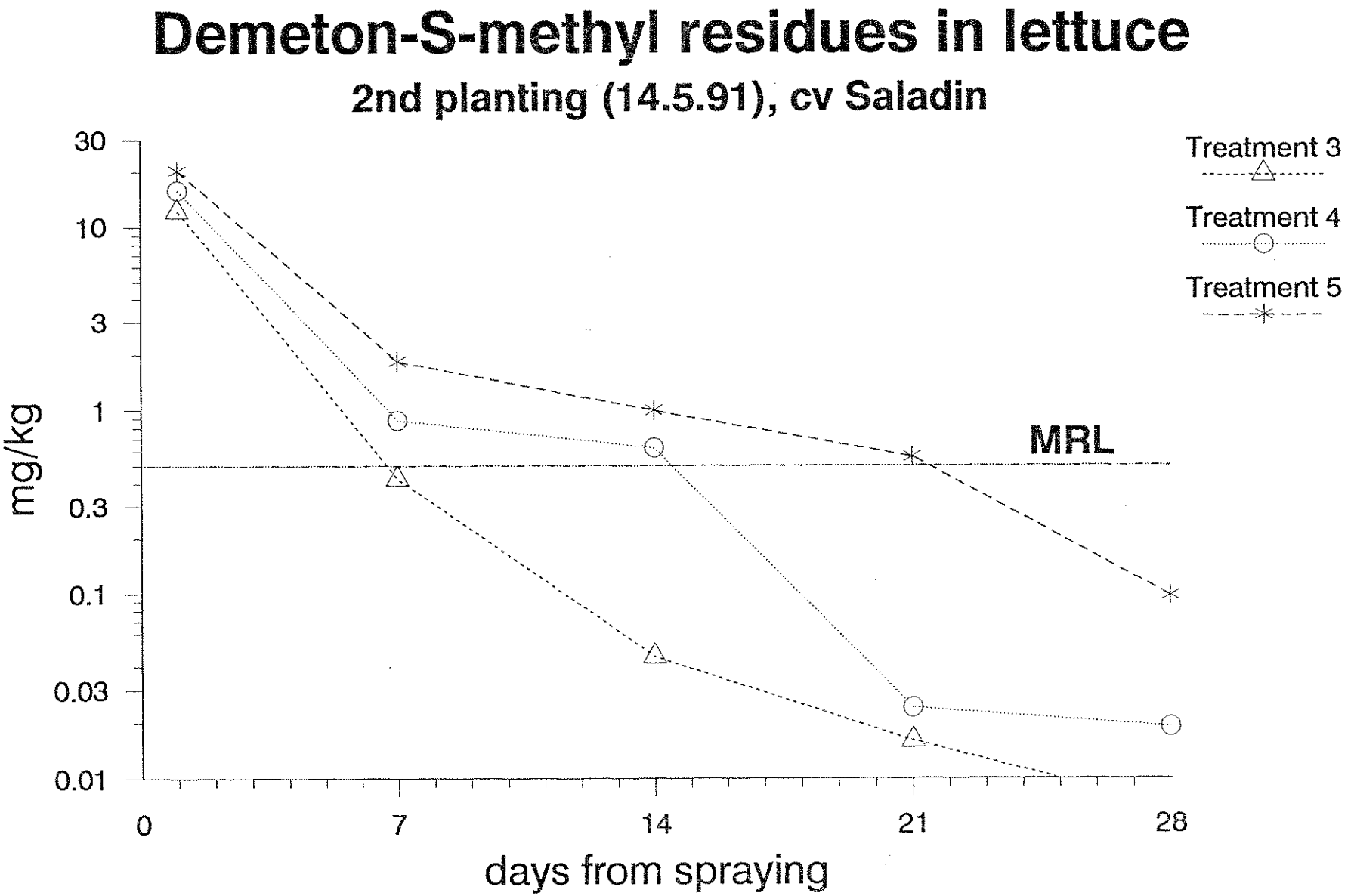

FIGURE 15: Decline of demeton-S-methyl residues in lettuce following application 1 day and 2 weeks (Treatment 3), 1 day and 4 weeks (Treatment 4) and 1 day and 6 weeks (Treatment 5) after planting in May 1991

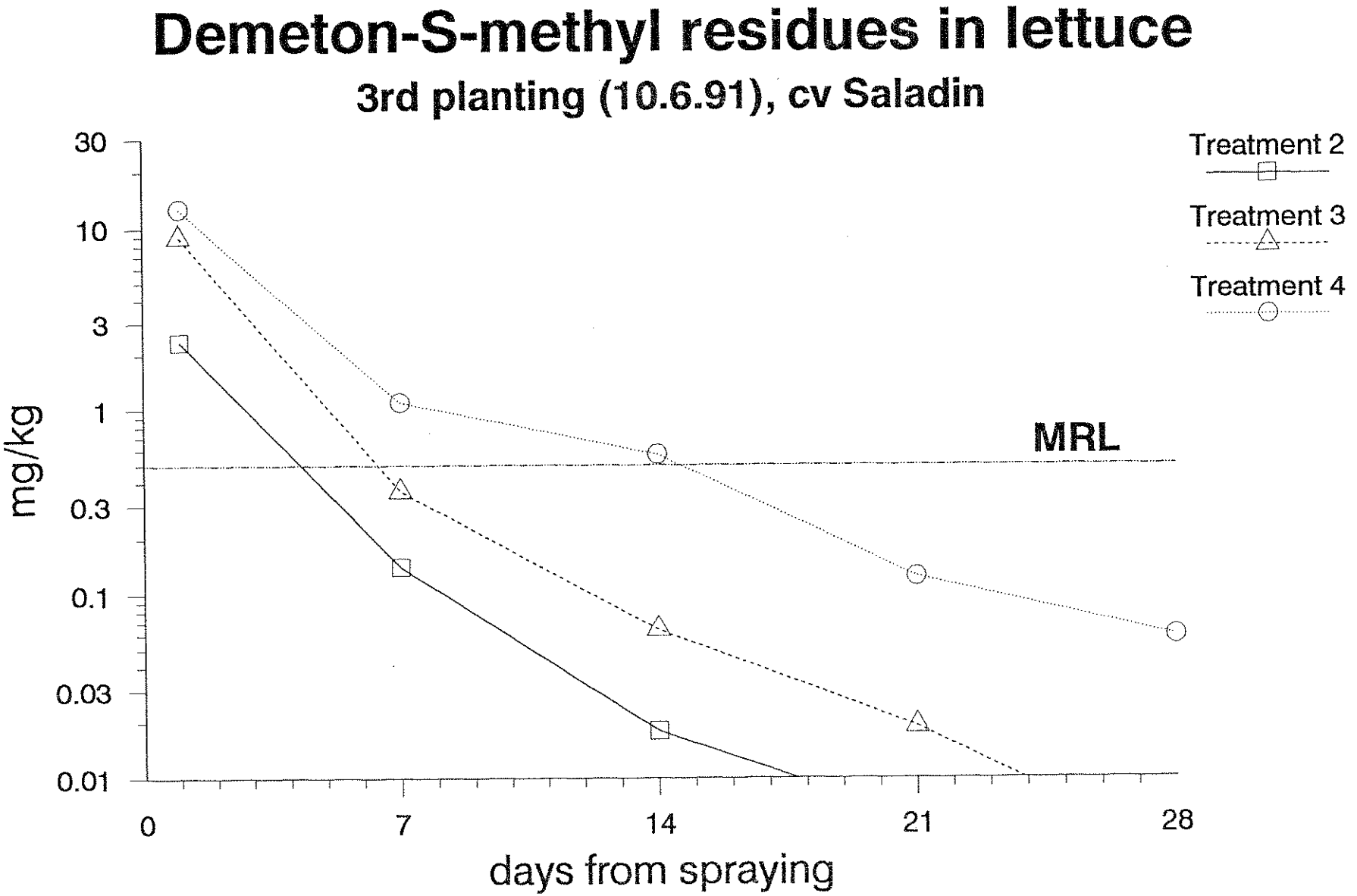

FIGURE 16: Decline of demeton-S-methyl residues in lettuce following application 1 day (Treatment 2), 1 day and 2 weeks (Treatment 3), 1 day and 4 weeks (Treatment 4) after planting in June 1991

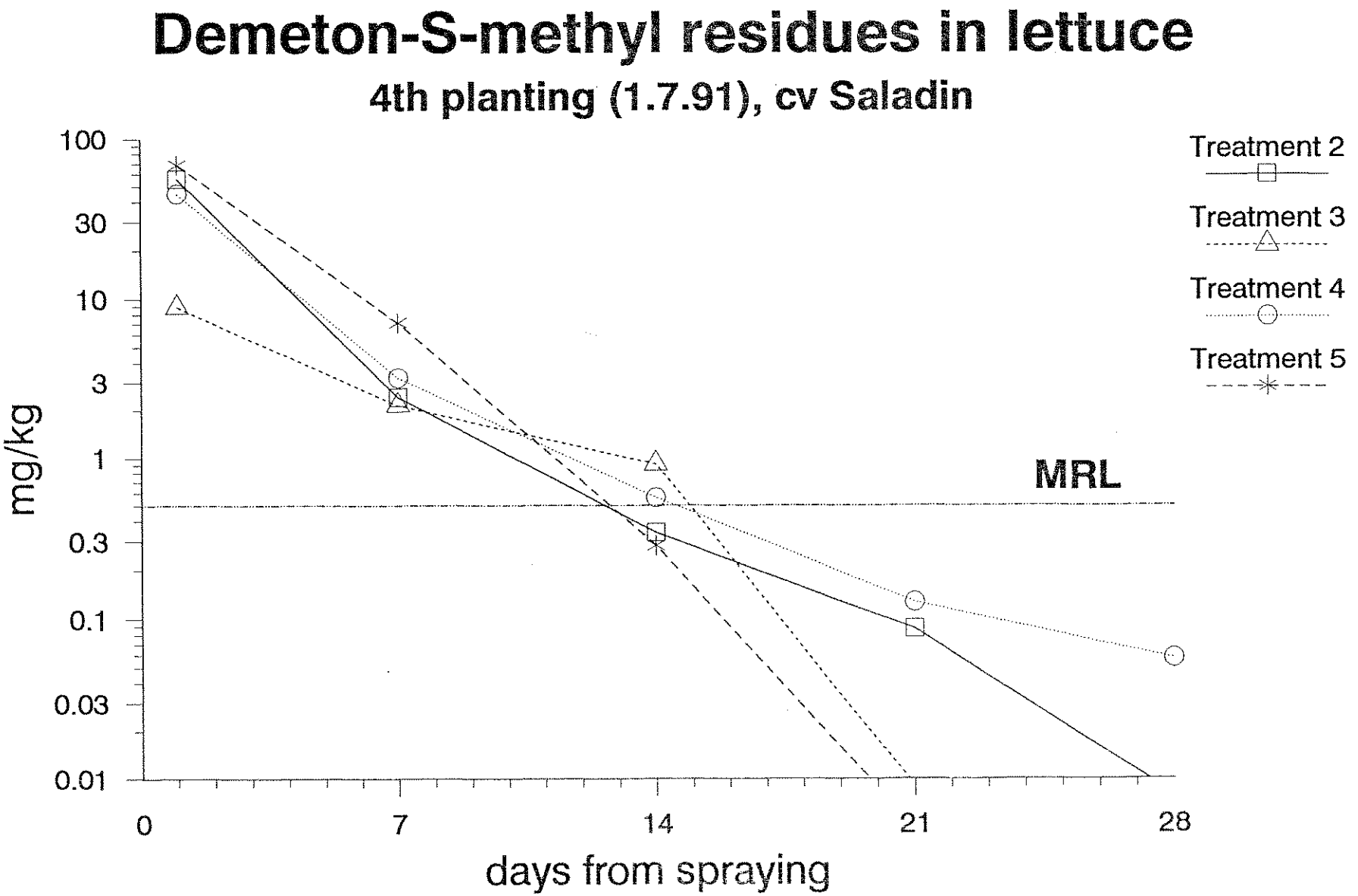

FIGURE 17: Decline of demeton-S-methyl residues in lettuce following application 1 day (Treatment 2), 1 day and 2 weeks (Treatment 3), 1 day and 4 weeks (Treatment 4) and 1 day and 6 weeks (Treatment 5) after planting in early July 1991

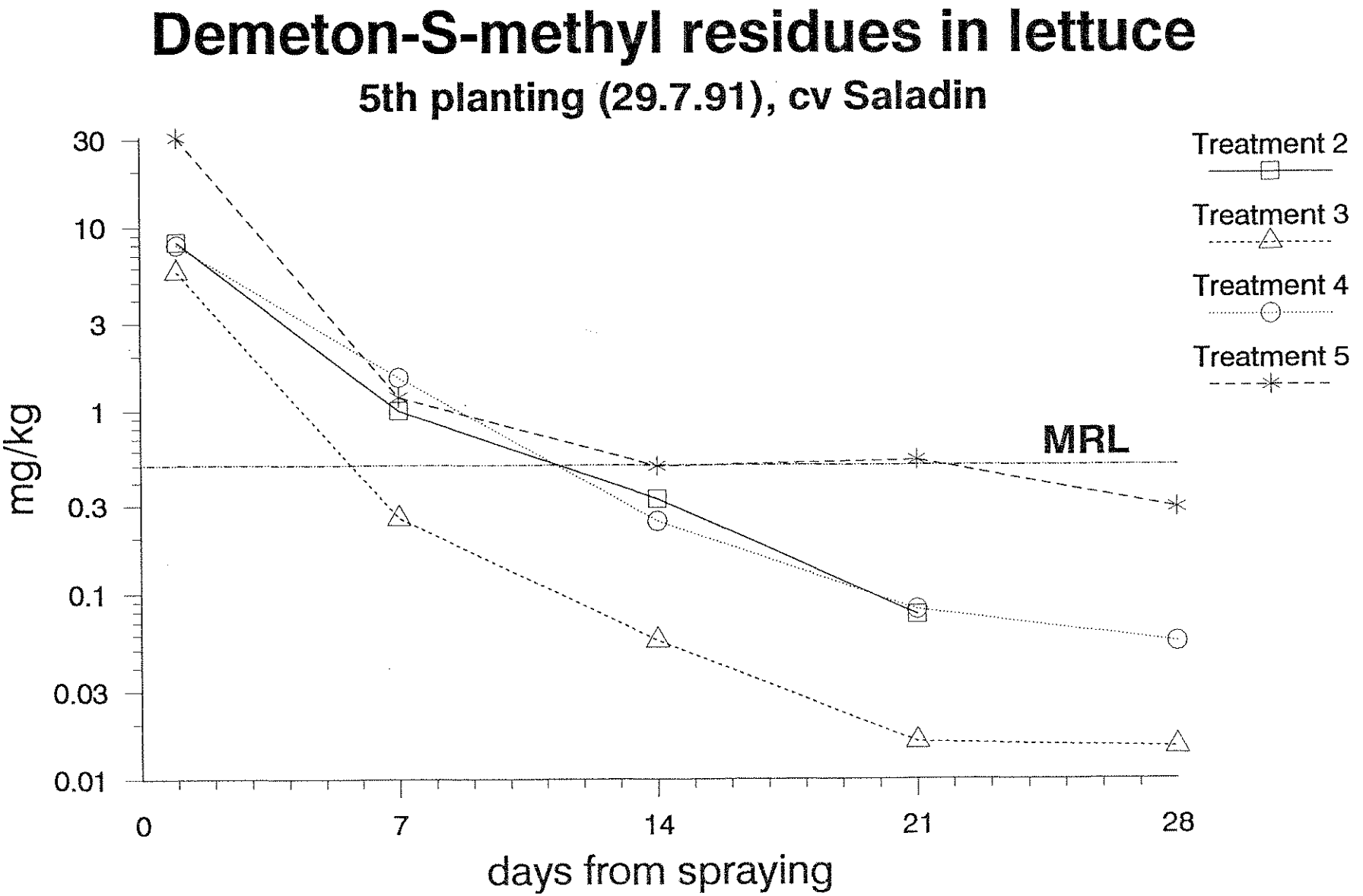

FIGURE 18: Decline of demeton-S-methyl residues in lettuce following application 1 day (Treatment 2), 1 day and 2 weeks (Treatment 3), 1 day and 4 weeks (Treatment 4) and 1 day and 6 weeks (Treatment 5) after planting in late July 1991

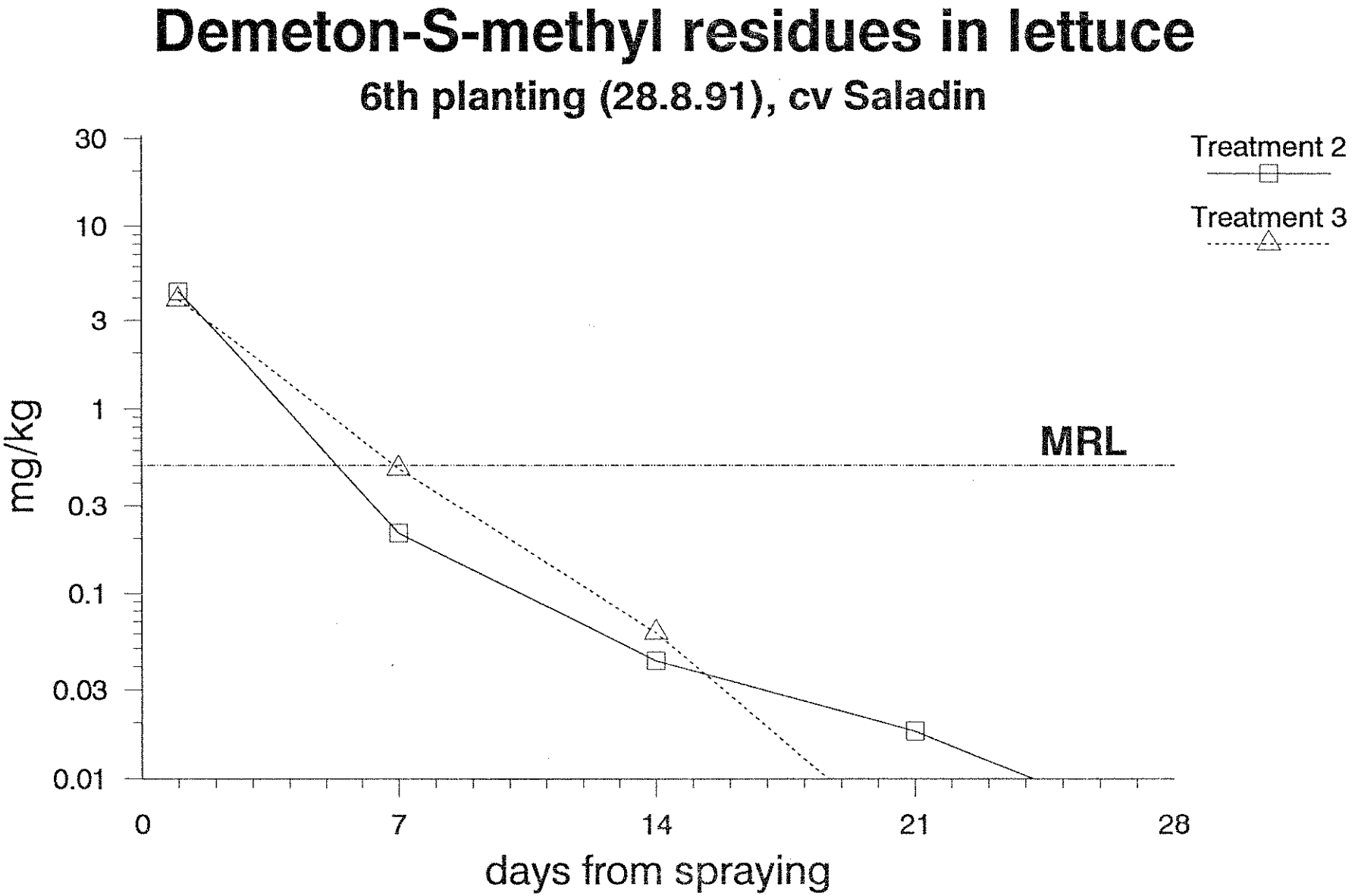

FIGURE 19: Decline of demeton-S-methyl residues in lettuce following application 1 day (Treatment 2) and 1 day and 2 weeks (Treatment 3) after planting in August 1991

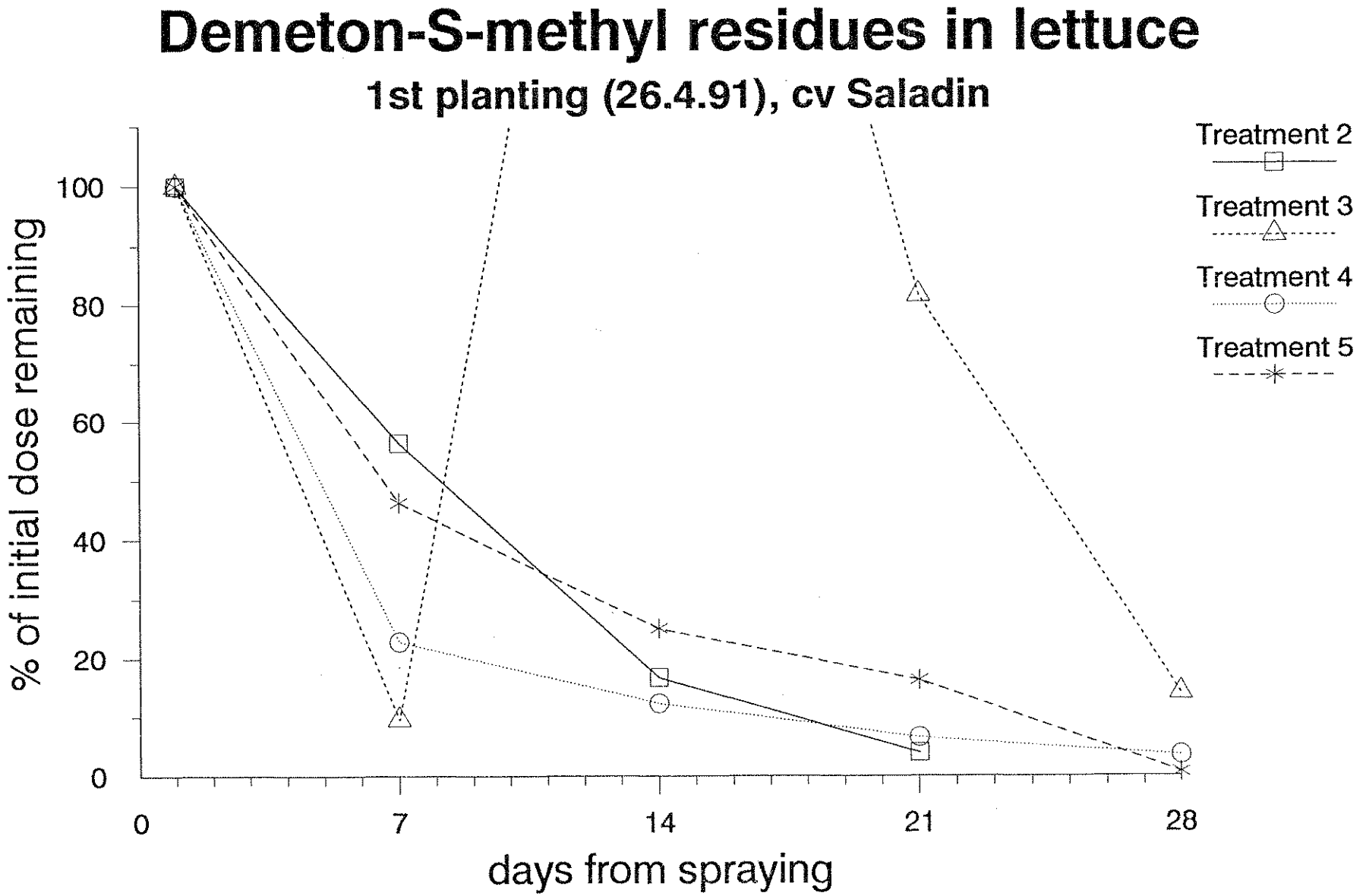

FIGURE 20: Proportional decline of demeton-S-methyl residues in lettuce following application 1 day (Treatment 2), 1 day and 2 weeks (Treatment 3), 1 day and 4 weeks (Treatment 4) and 1 day and 6 weeks (Treatment 5) after planting in April 1991

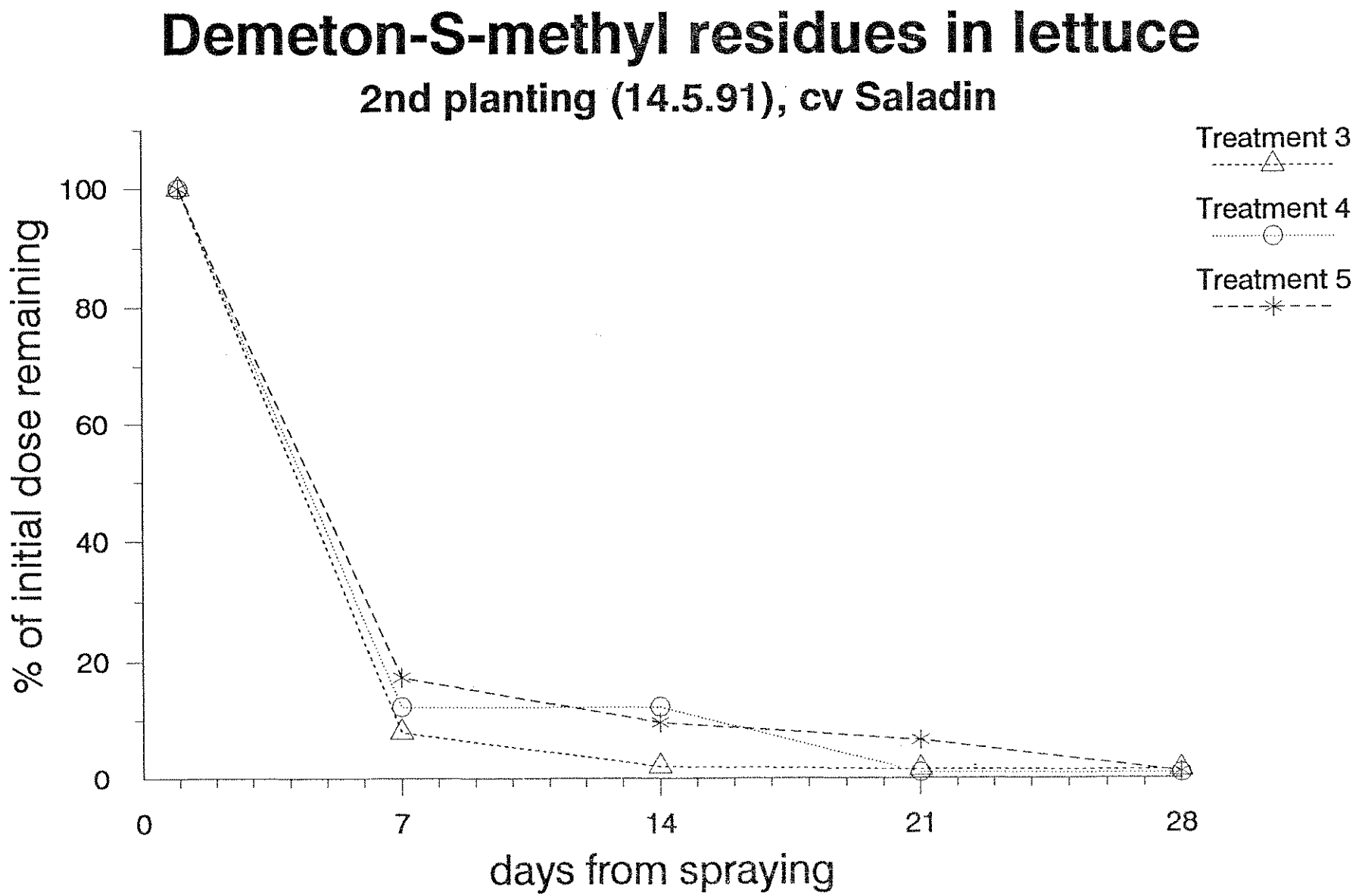

FIGURE 21: Proportional decline of demeton-S-methyl residues in lettuce following application 1 day and 2 weeks (Treatment 3), 1 day and 4 weeks (Treatment 4) and 1 day and 6 weeks (Treatment 5) after planting in May 1991

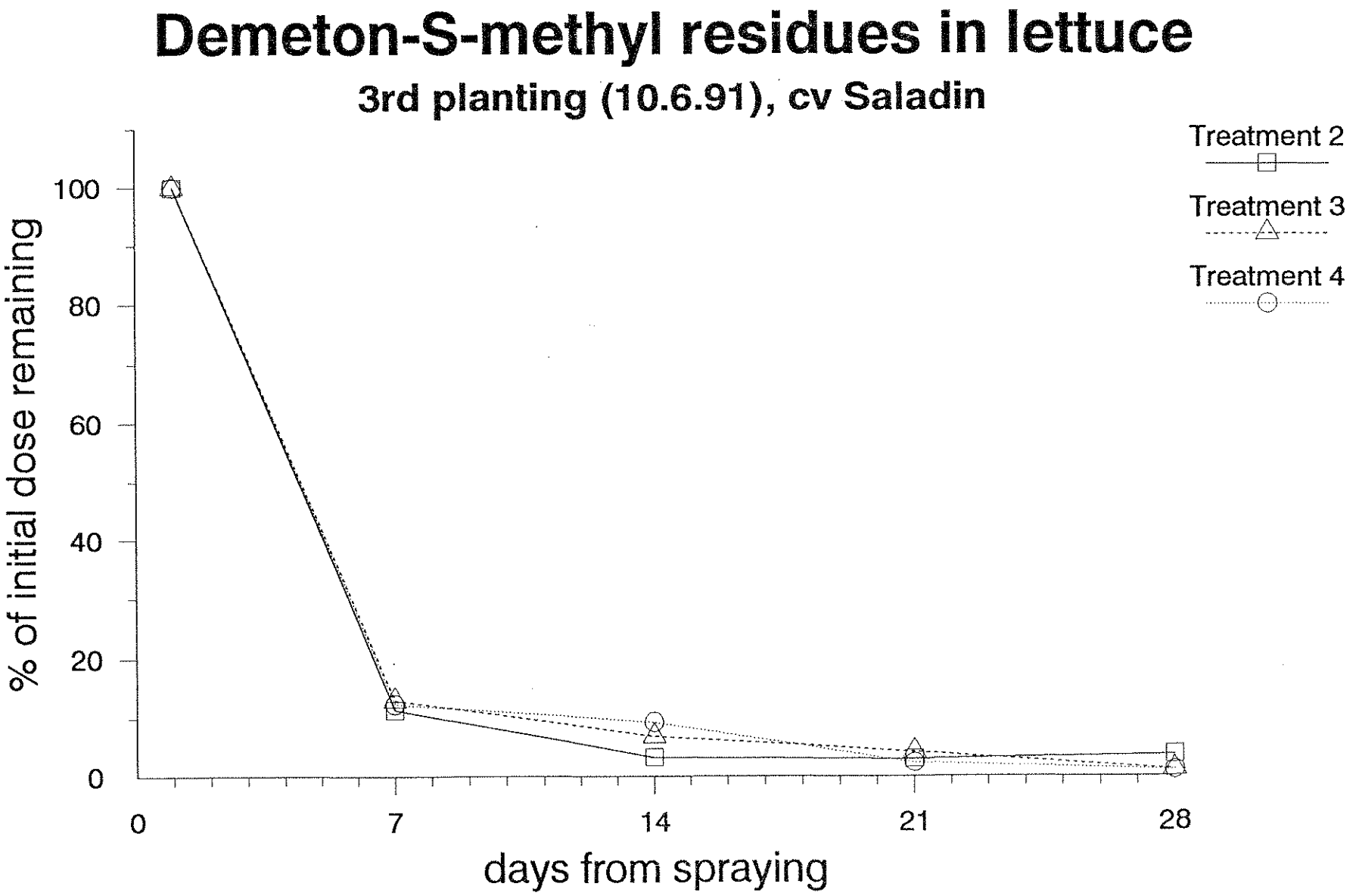

FIGURE 22: Proportional decline of demeton-S-methyl residues in lettuce following application 1 day (Treatment 2), 1 day and 2 weeks (Treatment 3), 1 day and 4 weeks (Treatment 4) after planting in June 1991

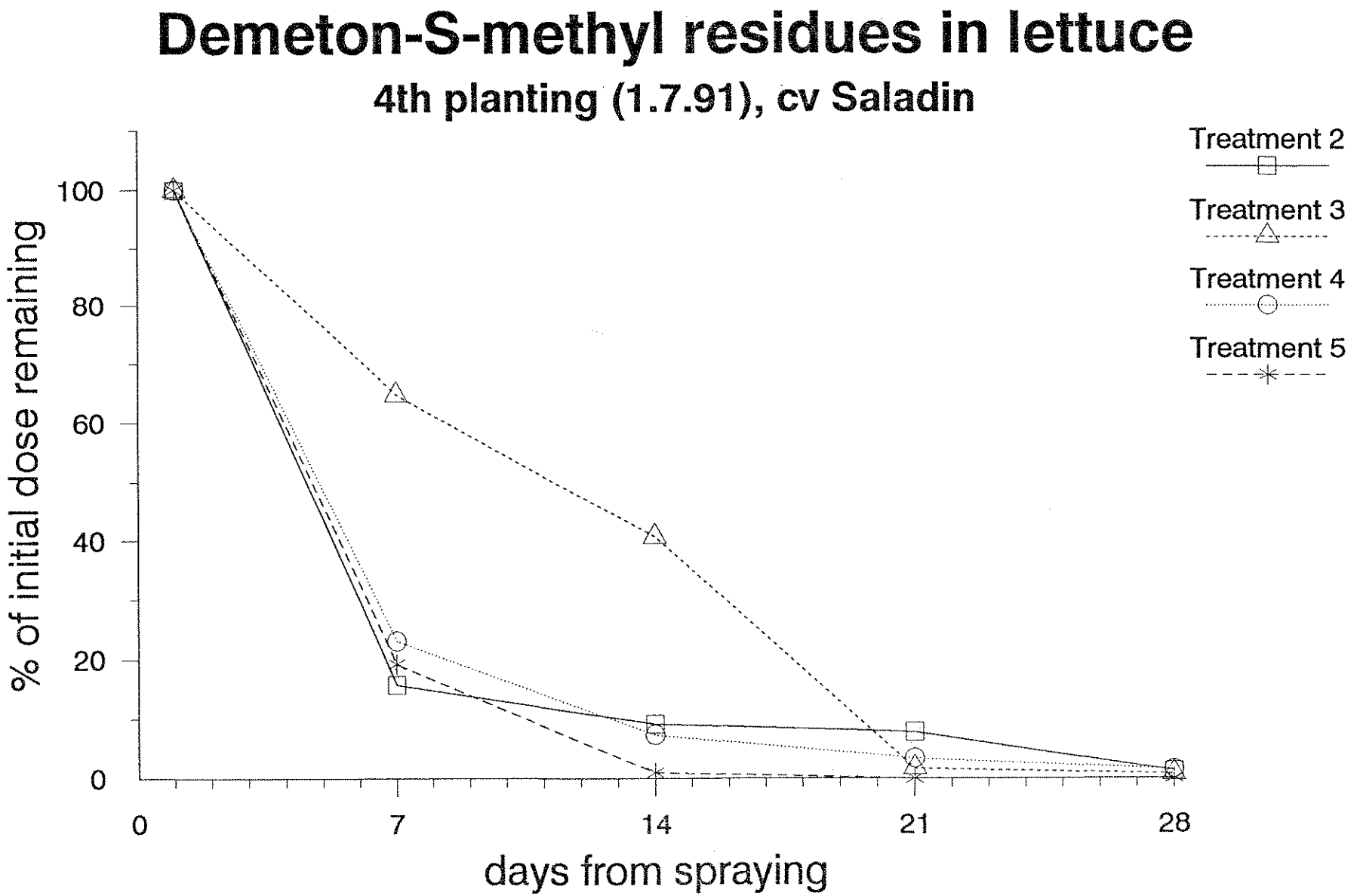

FIGURE 23: Proportional decline of demeton-S-methyl resiudes in lettuce following application 1 day (Treatment 2), 1 day and 2 weeks (Treatment 3), 1 day and 4 weeks (Treatment 4) and 1 day and 6 weeks (Treatment 5) after planting in early July 1991

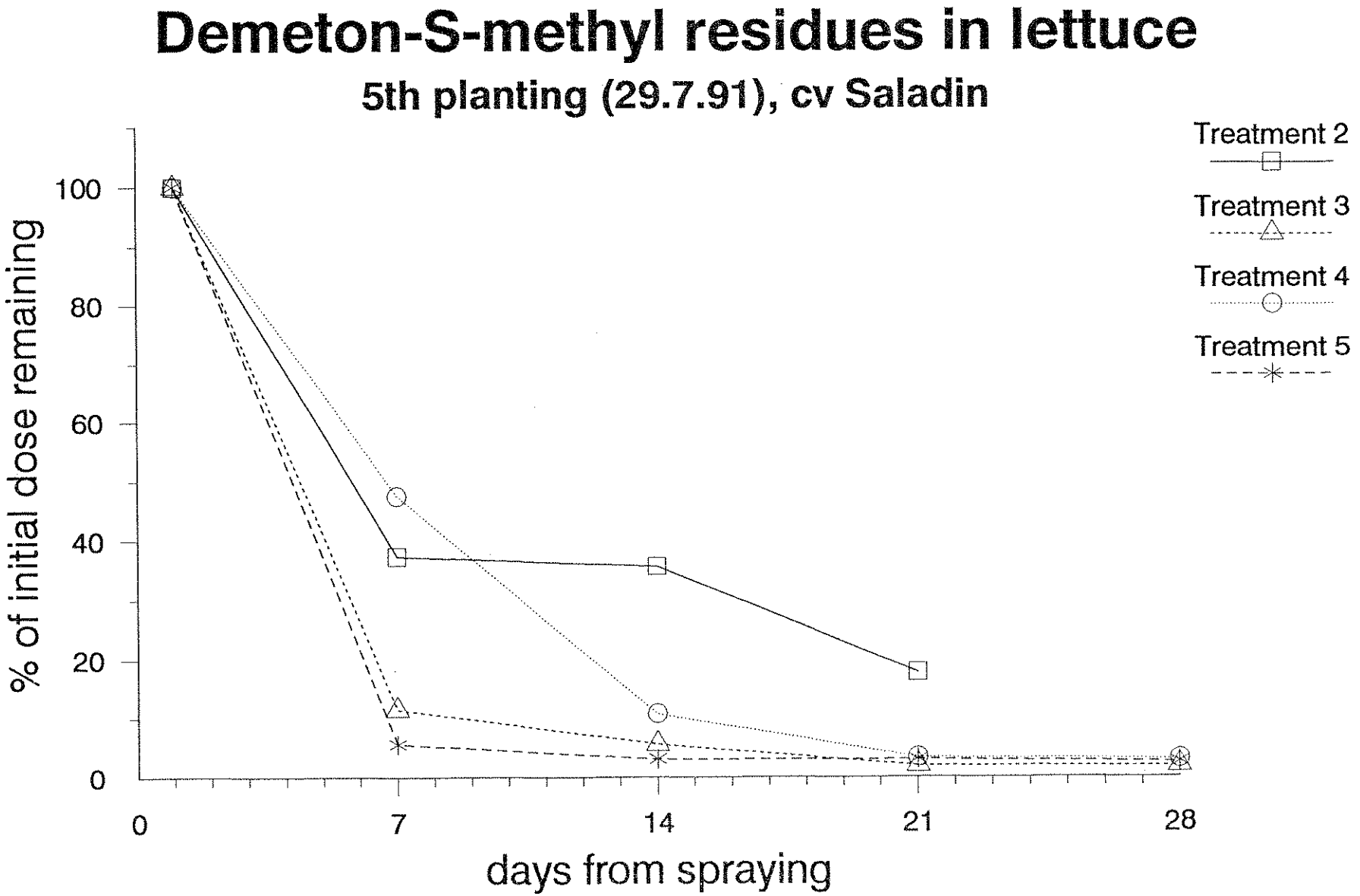

FIGURE 24: Proportional decline of demeton-S-methyl residues in lettuce following application 1 day (Treatment 2), 1 day and 2 weeks (Treatment 3), 1 day and 4 weeks (Treatment 4) and 1 day and 6 weeks (Treatment 5) after planting in late July 1991

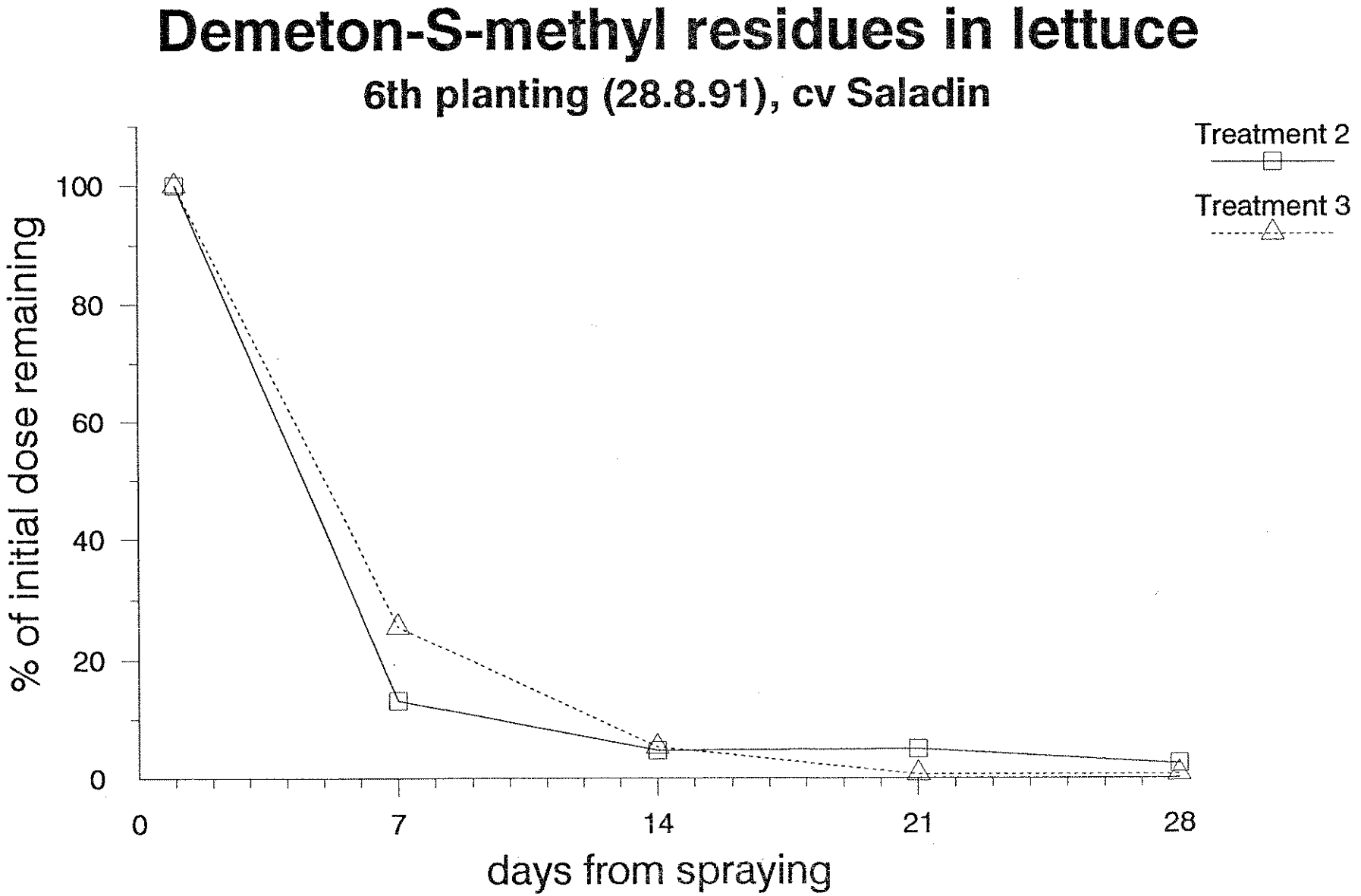

FIGURE 25: Proportional decline of demeton-S-methyl residues in lettuce following application 1 day (Treatment 2) and 1 day and 2 weeks (Treatment 3) after planting in August 1991

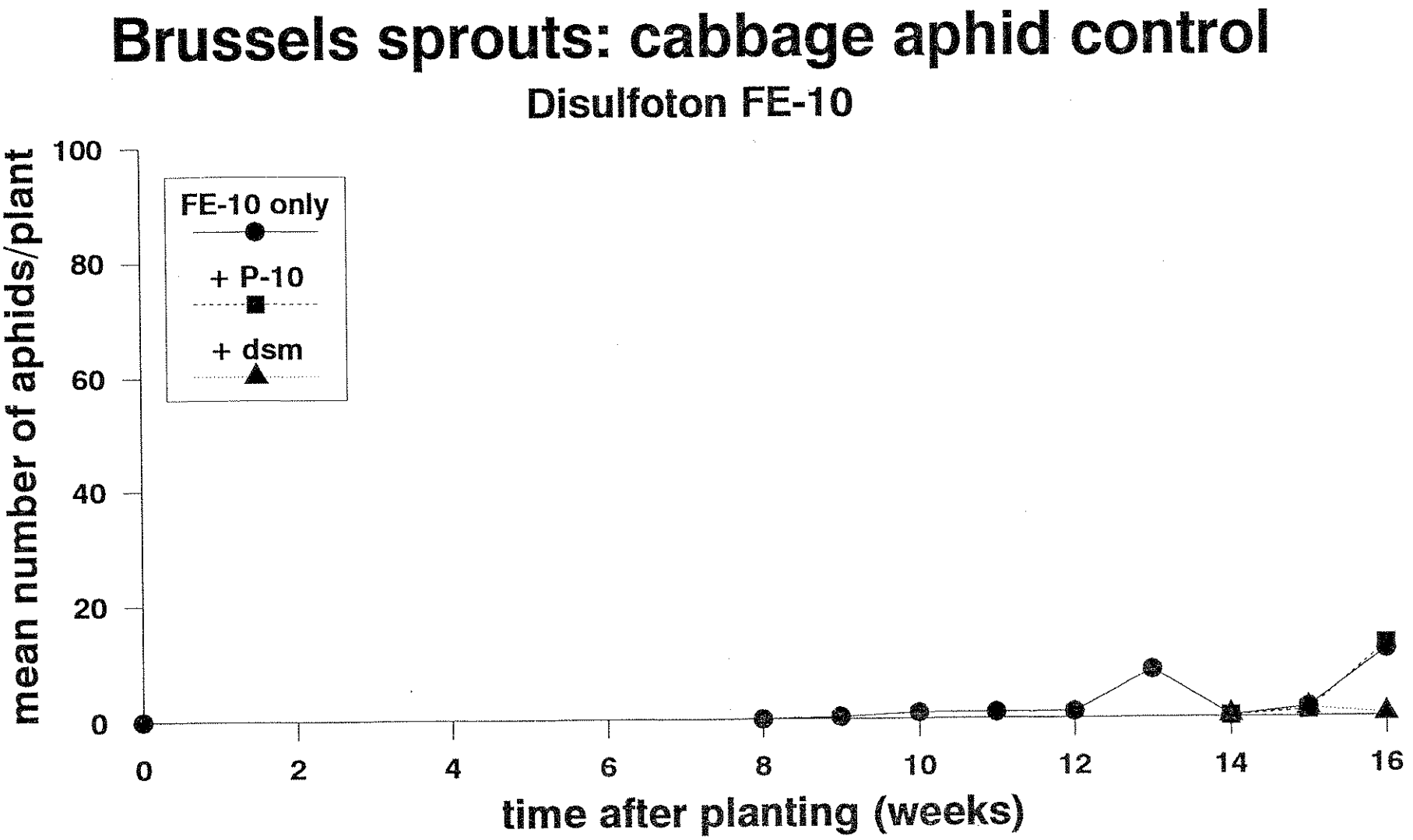

FIGURE 26. Numbers of cabbage aphids on Brussels sprouts following application of the recommended dose of disulfoton FE.10 in early May supplemented with foliar applications of disulfoton P.10 or demeton-S-methyl (dsm).

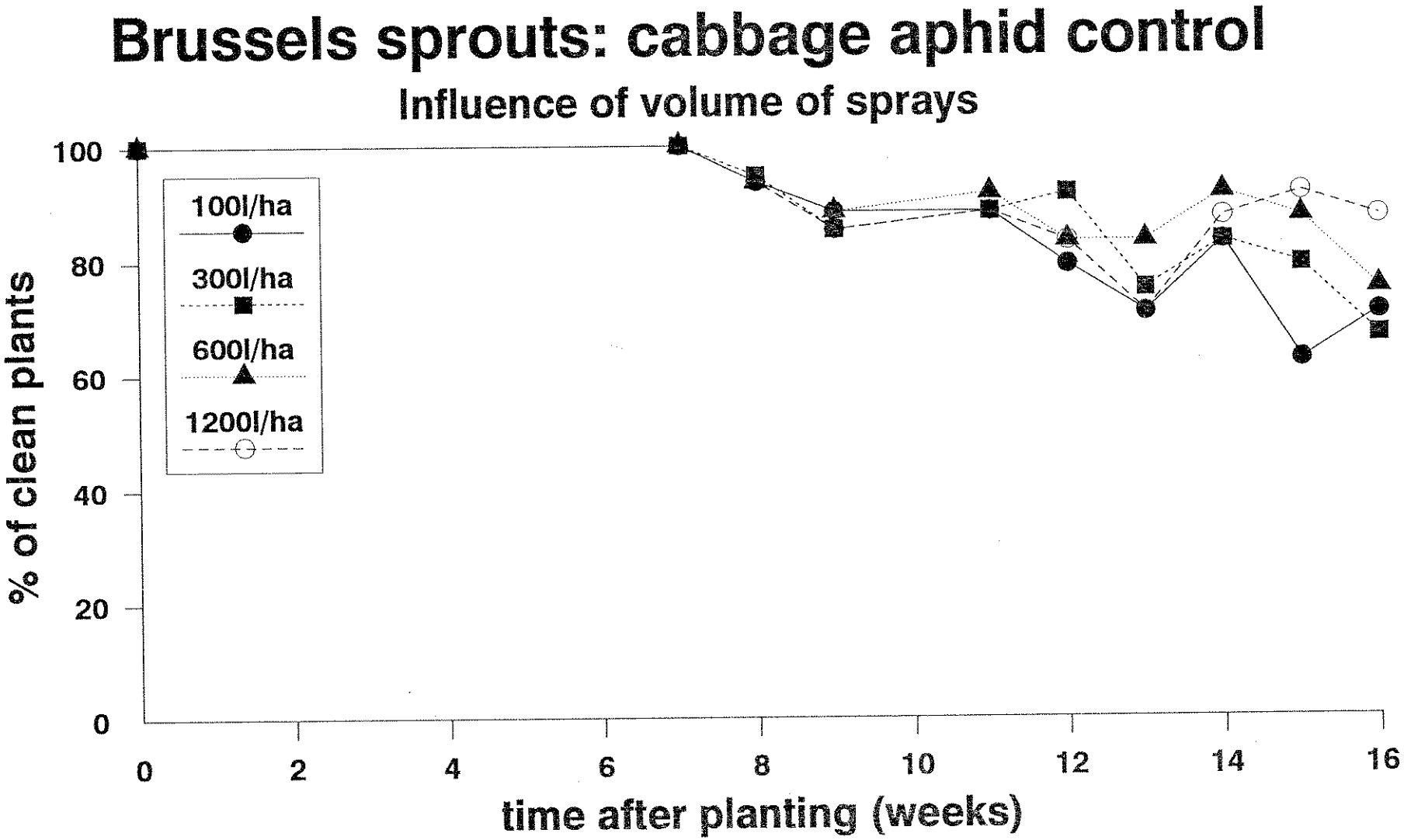

FIGURE 27: Proportions of aphid-free Brussels sprouts following 4 applications of the recommended dose of demeton-S-methyl in different volumes of water.

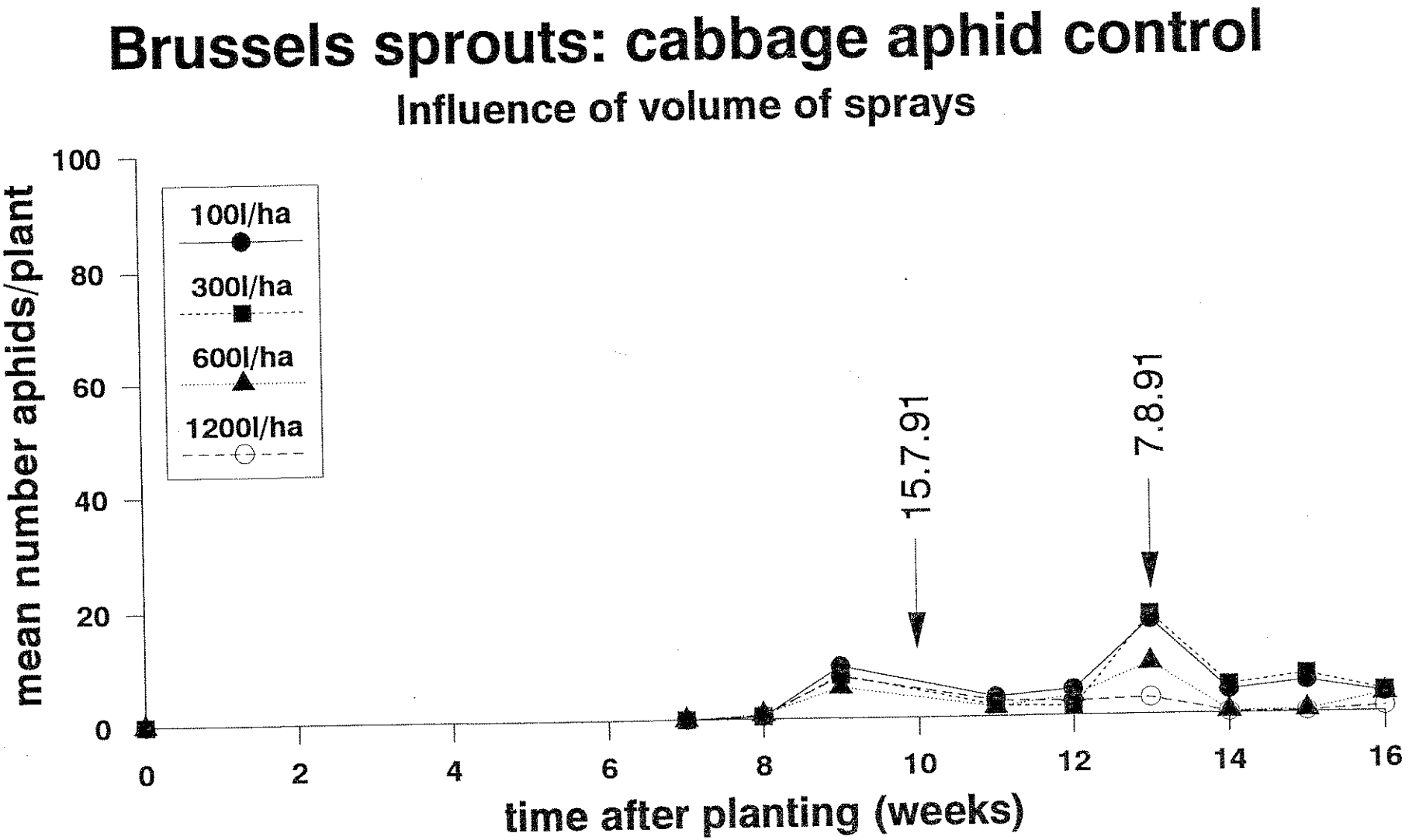

FIGURE 28: Numbers of cabbage aphids on Brussels sprouts following 4 applications of the recommended dose of demeton-S-methyl in different volumes of water.

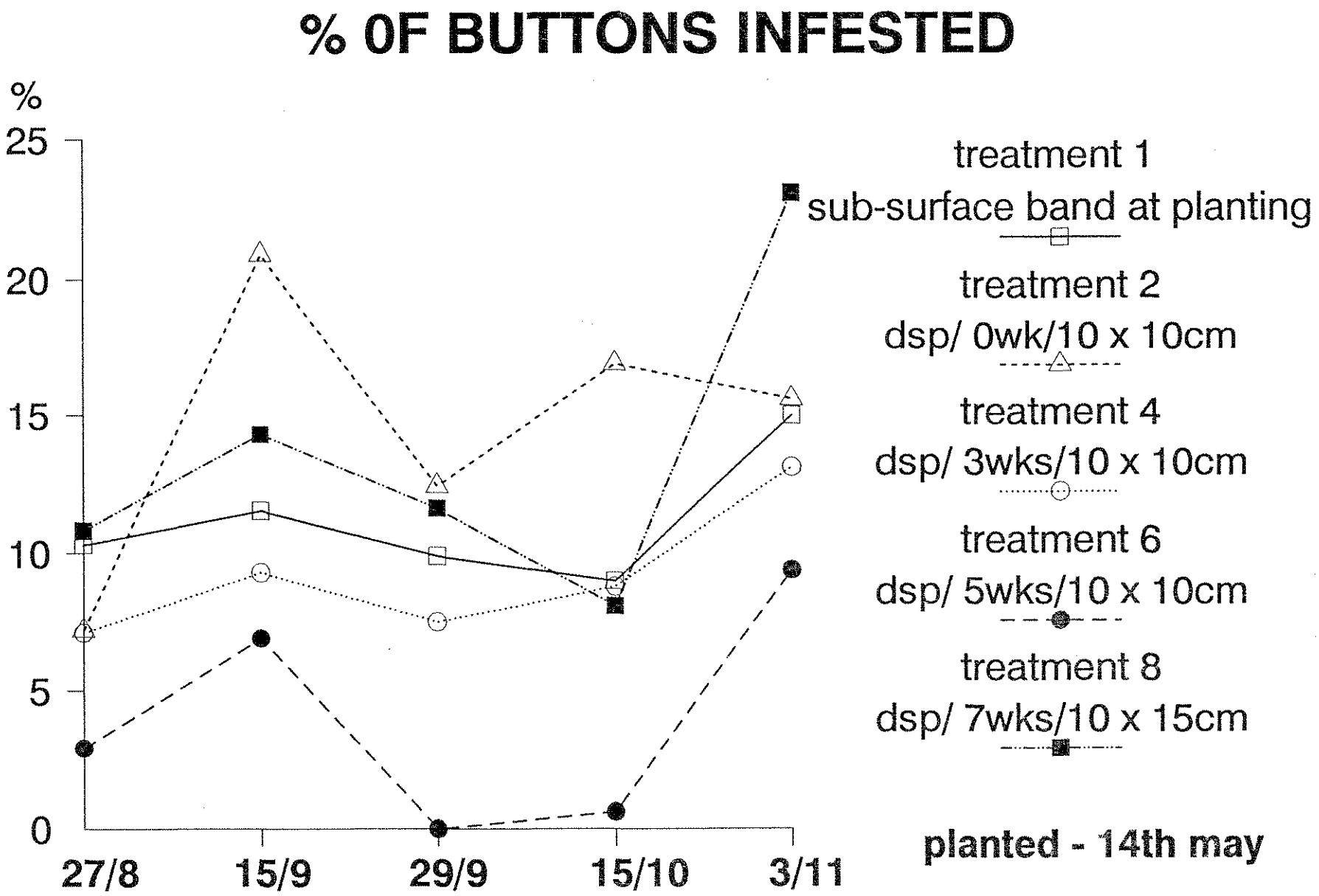

FIGURE 29: Proportions of Brussels sprouts buttons containing at least one aphid following application of disulfoton FE.10 as a sub-surface band or as a deep side-placement (10 x 10, 10 x 15 cm).

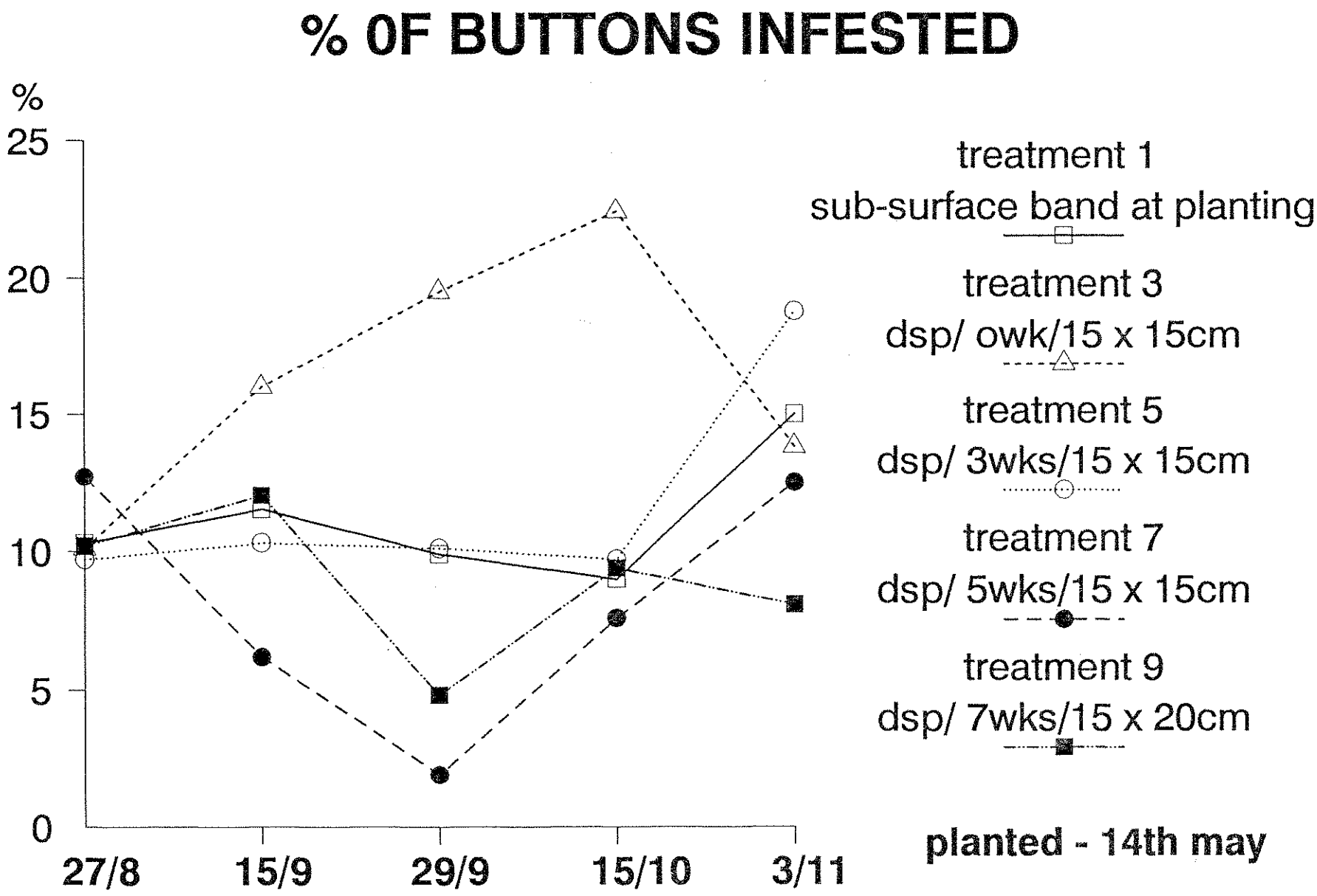

FIGURE 30: Proportions of Brussels sprout buttons containing at least one aphid following application of disulfoton FE.10 as a sub-surface band or as a deep side-placement (15 x 15, 15 x 20 cm)

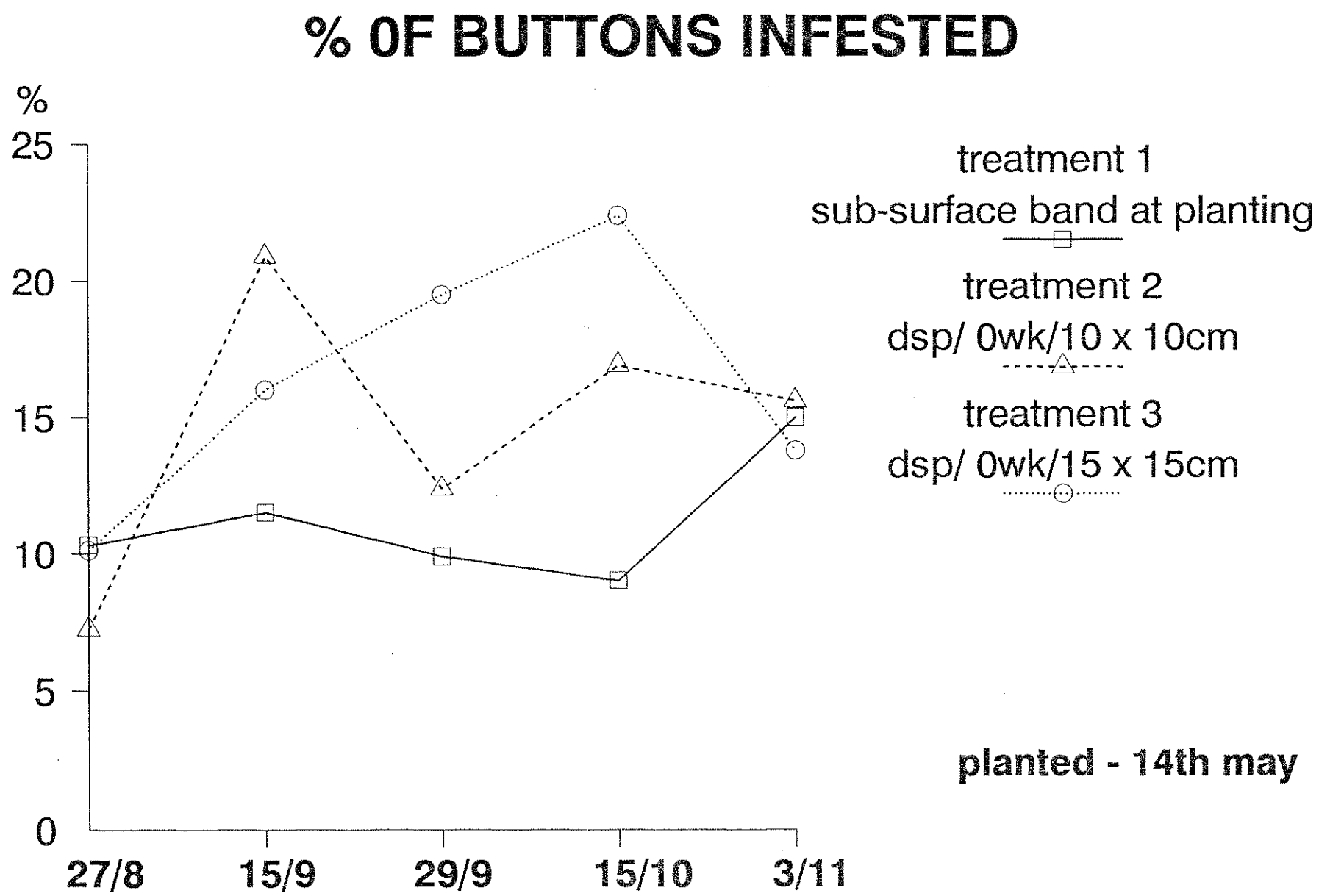

FIGURE 31: Proportions of Brussels sprout buttons containing at least one aphid following application of disulfoton FE.10 at planting time as a sub-surface band or as deep side-placements

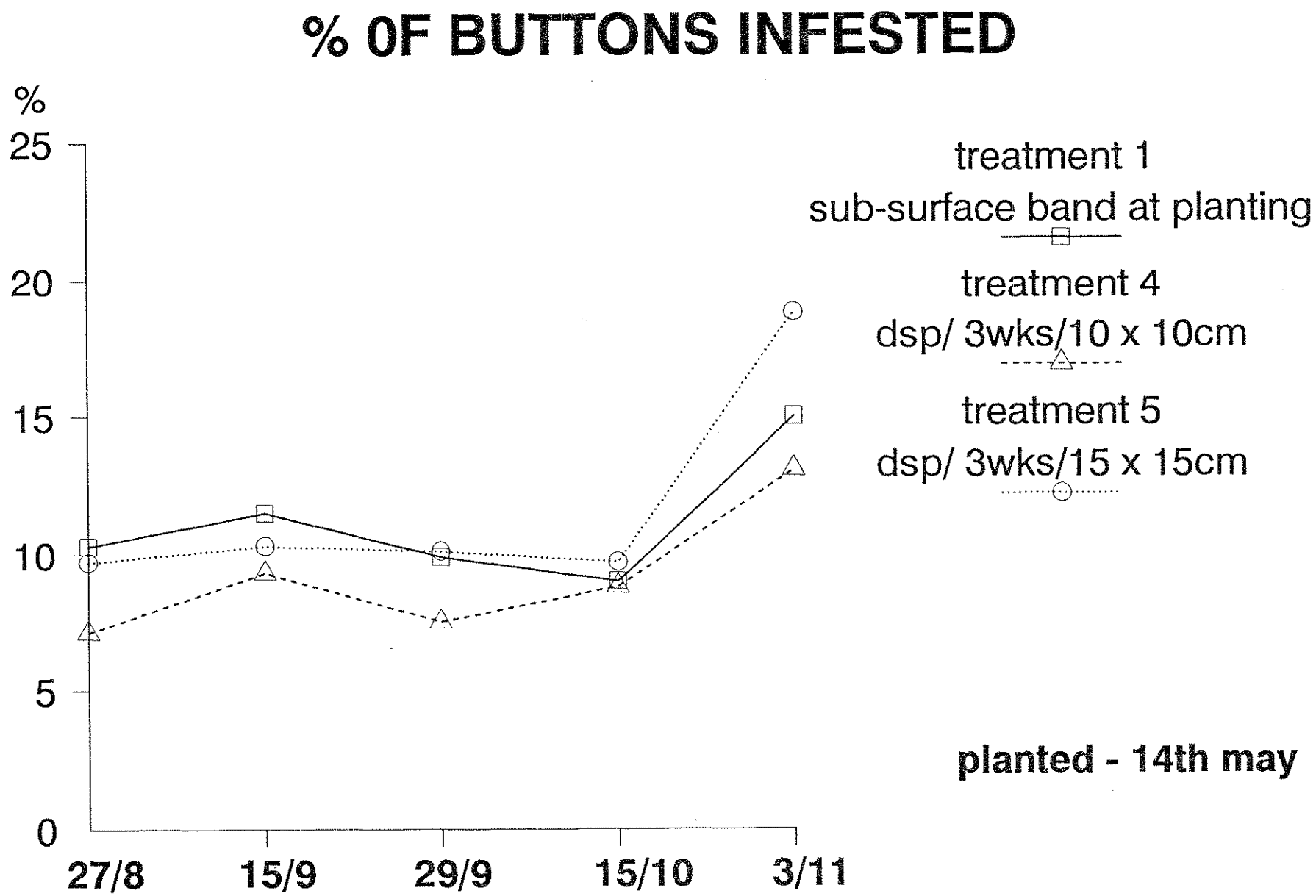

FIGURE 32: Proportions of Brussels sprout buttons containing at least one aphid following application of disulfoton FE.10 as a sub-surface band at planting-time or as deep side-placements 3 weeks after planting.

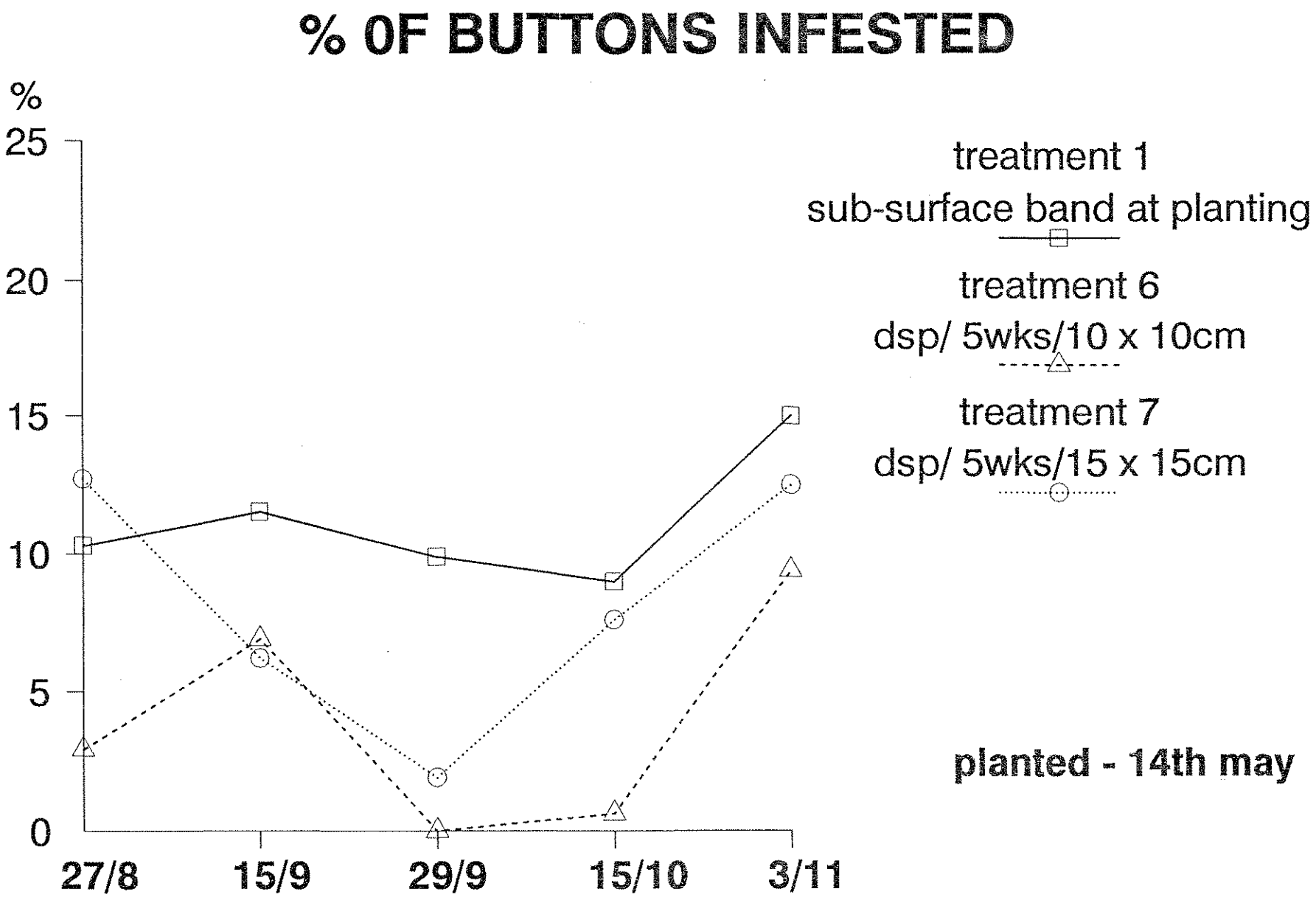

FIGURE 33: Proportions of Brussels sprout buttons containing at least one aphid following application of disulfoton FE.10 as a sub-surface band at planting-time or as deep side-placements 5 weeks after planting.

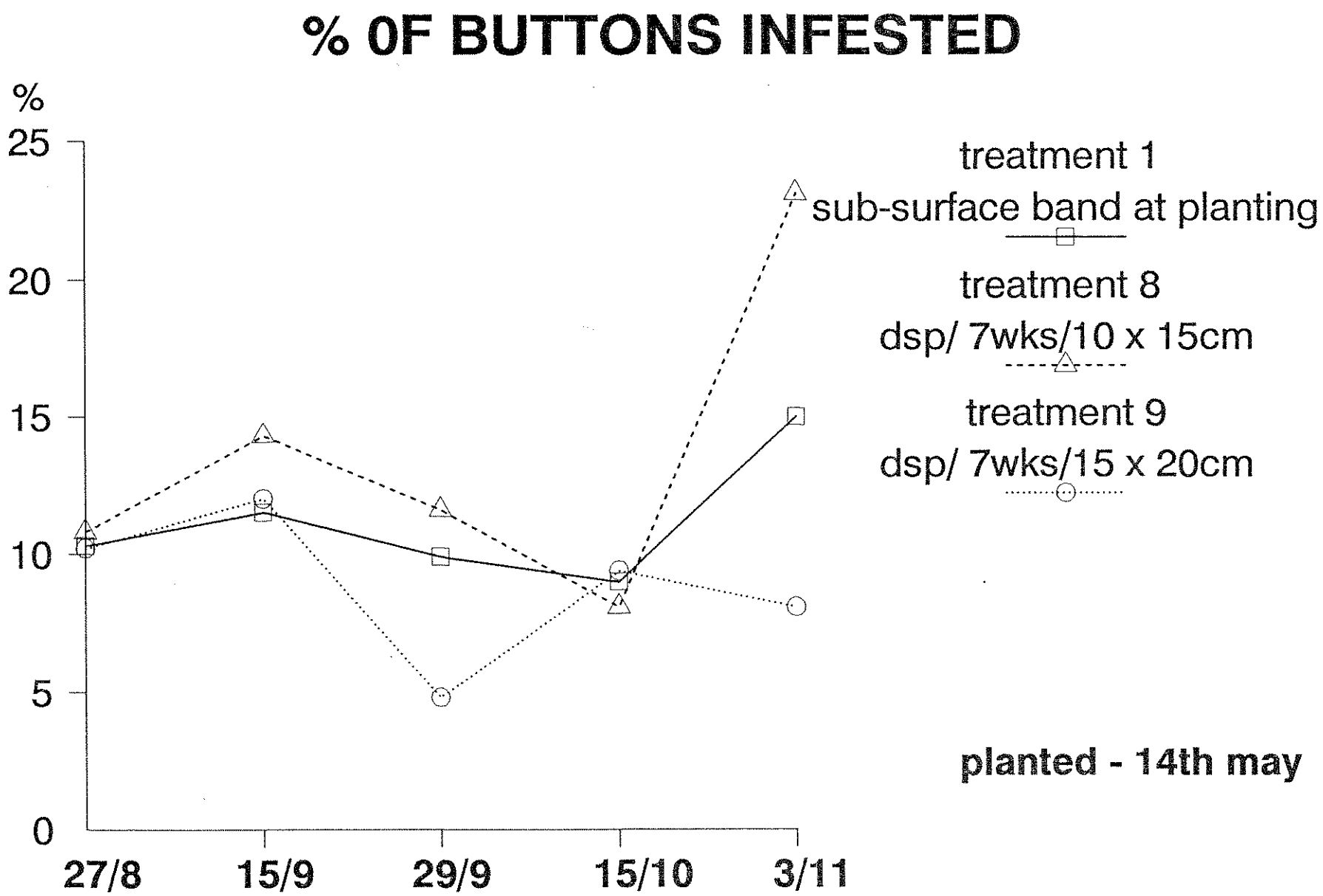

FIGURE 34: Proportions of Brussels sprout buttons containing at least one aphid following application of disulfoton FE.10 as a sub-surface band at planting-time or as deep side-placements 7 weeks after planting.

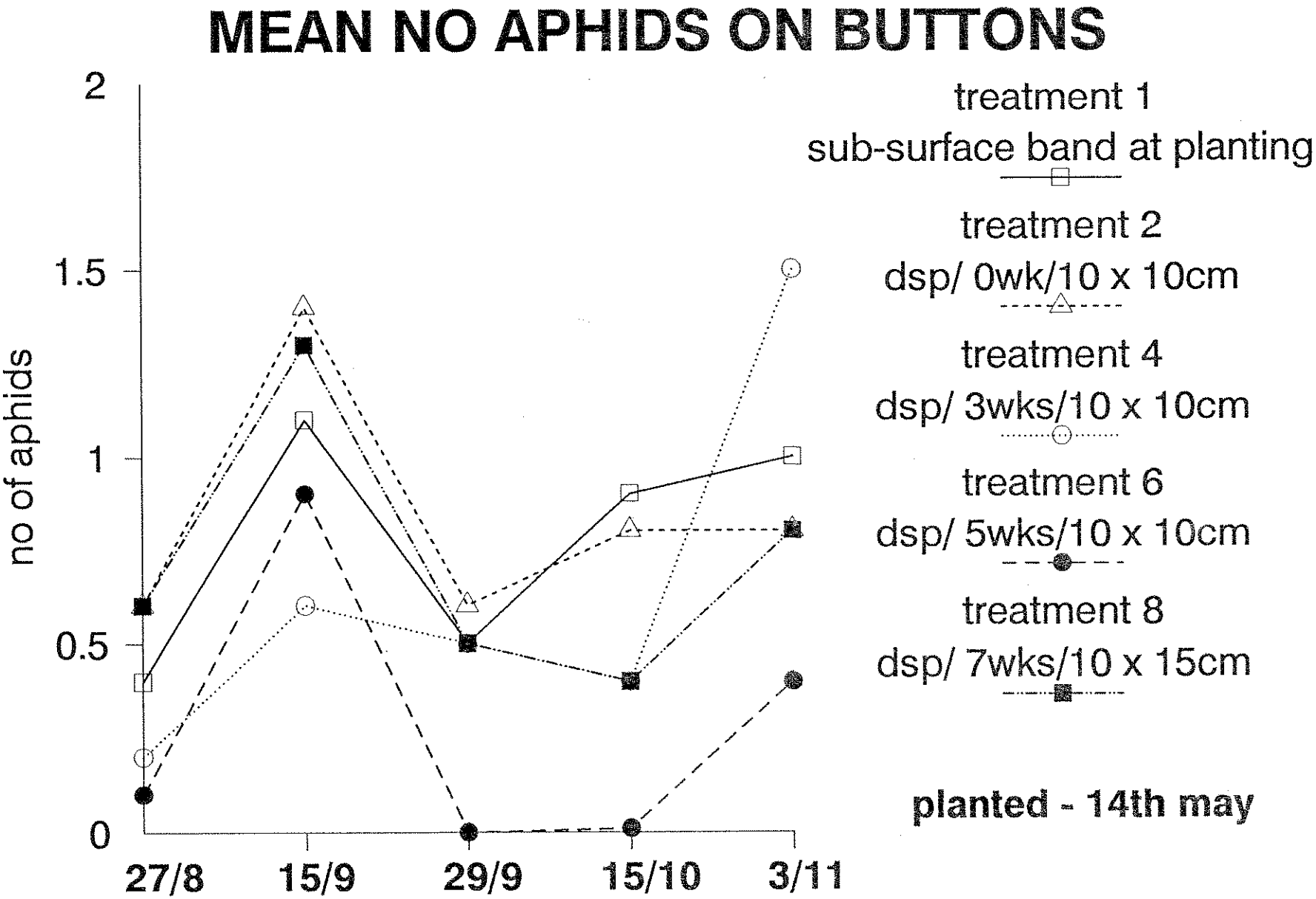

FIGURE 35:Mean numbers of cabbage aphids per sprout button following application of disulfoton FE.10 as a sub-surface band or as a deep side-placement (10 x 10, 10 x 15 cm)

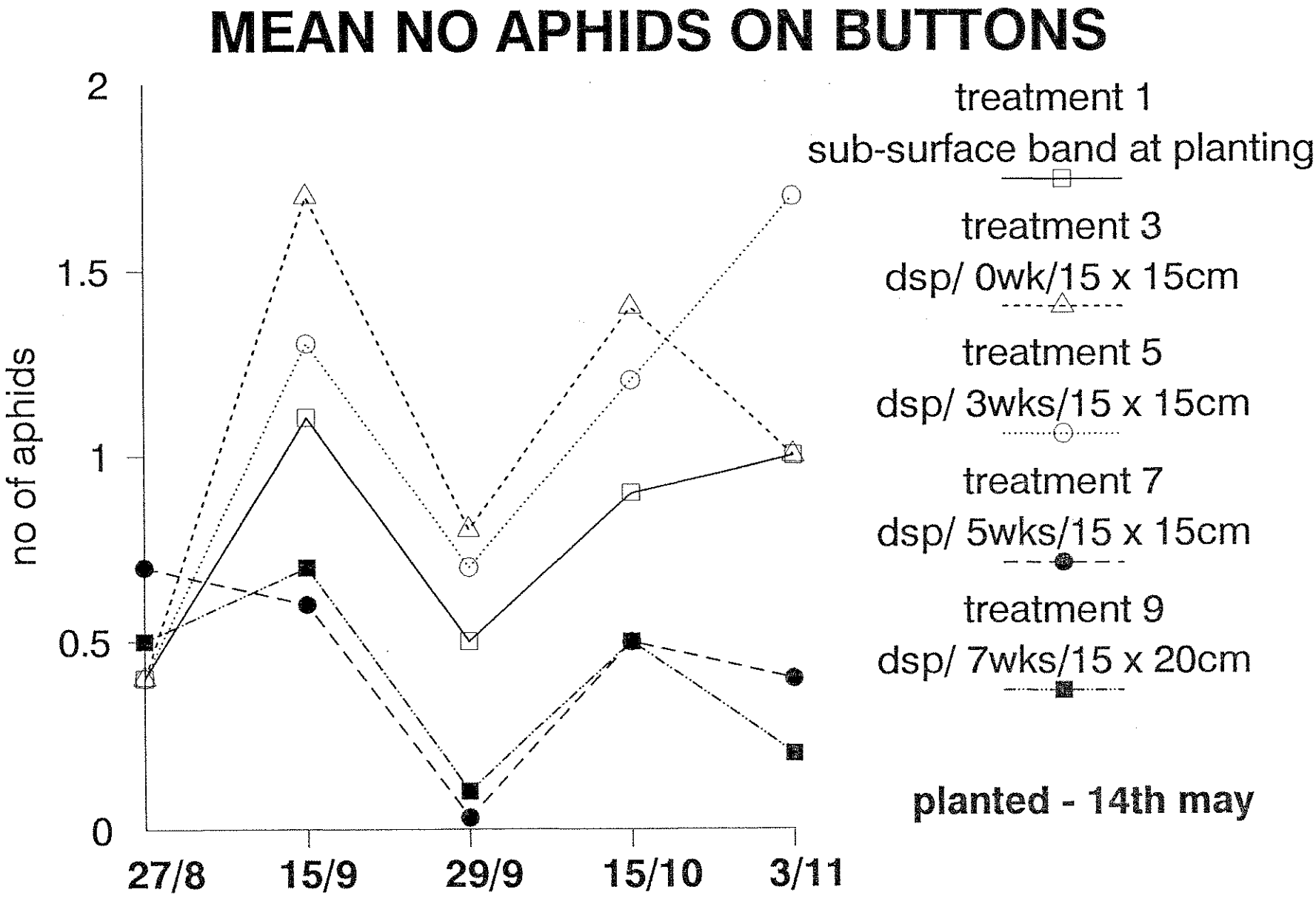

FIGURE 36: Mean numbers of cabbage aphids per sprout button following application of disulfoton FE.10 as a sub-surface band or as a deep side-placement (15 x 15, 15 x 20 cm)

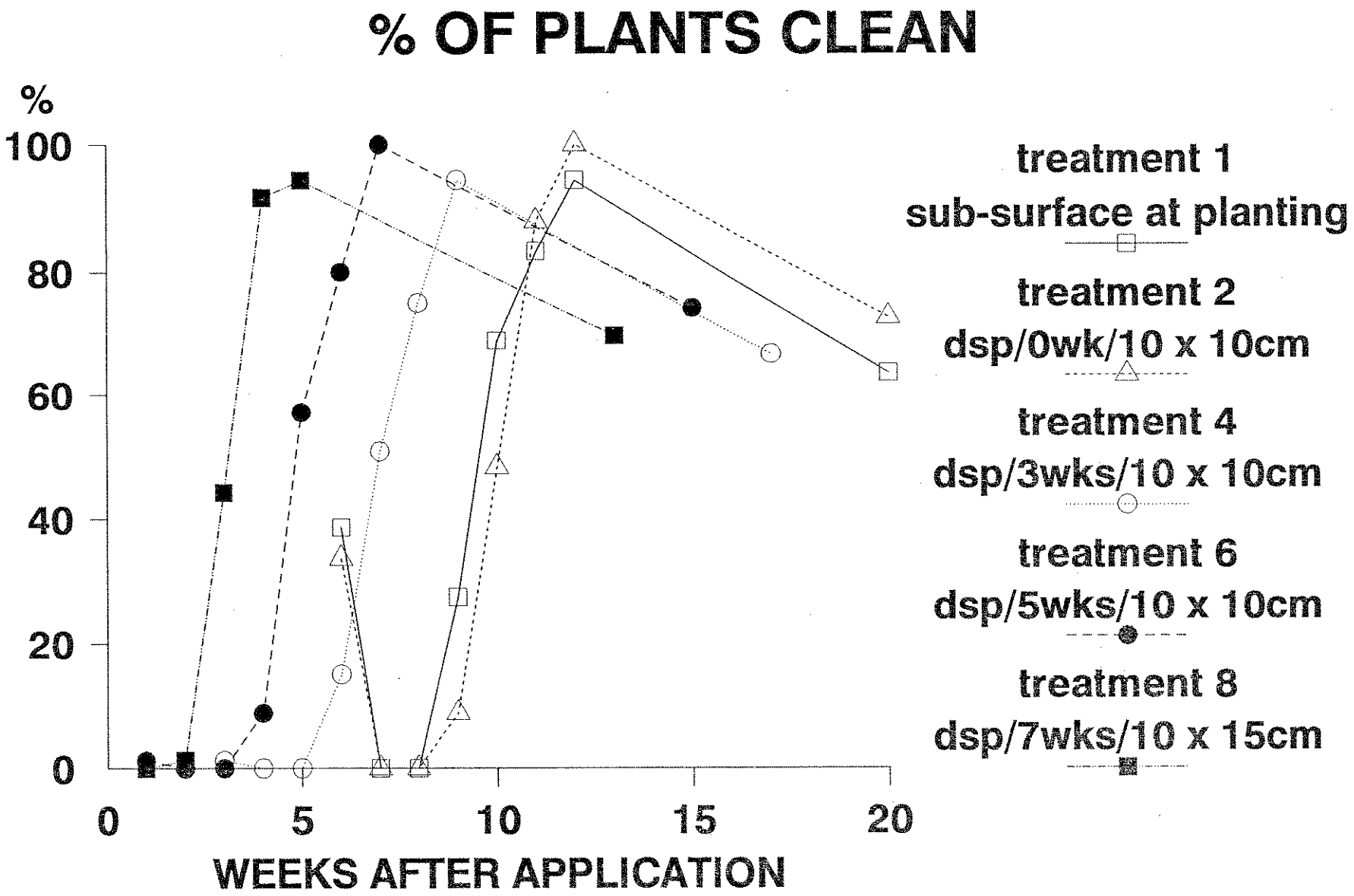

FIGURE 37: Proportions of aphid-free Brussels sprouts plants at intervals after application of disulfoton FE.10 as a sub-surface band or as a deep side-placement (10 x 10, 10 x 15 cm)

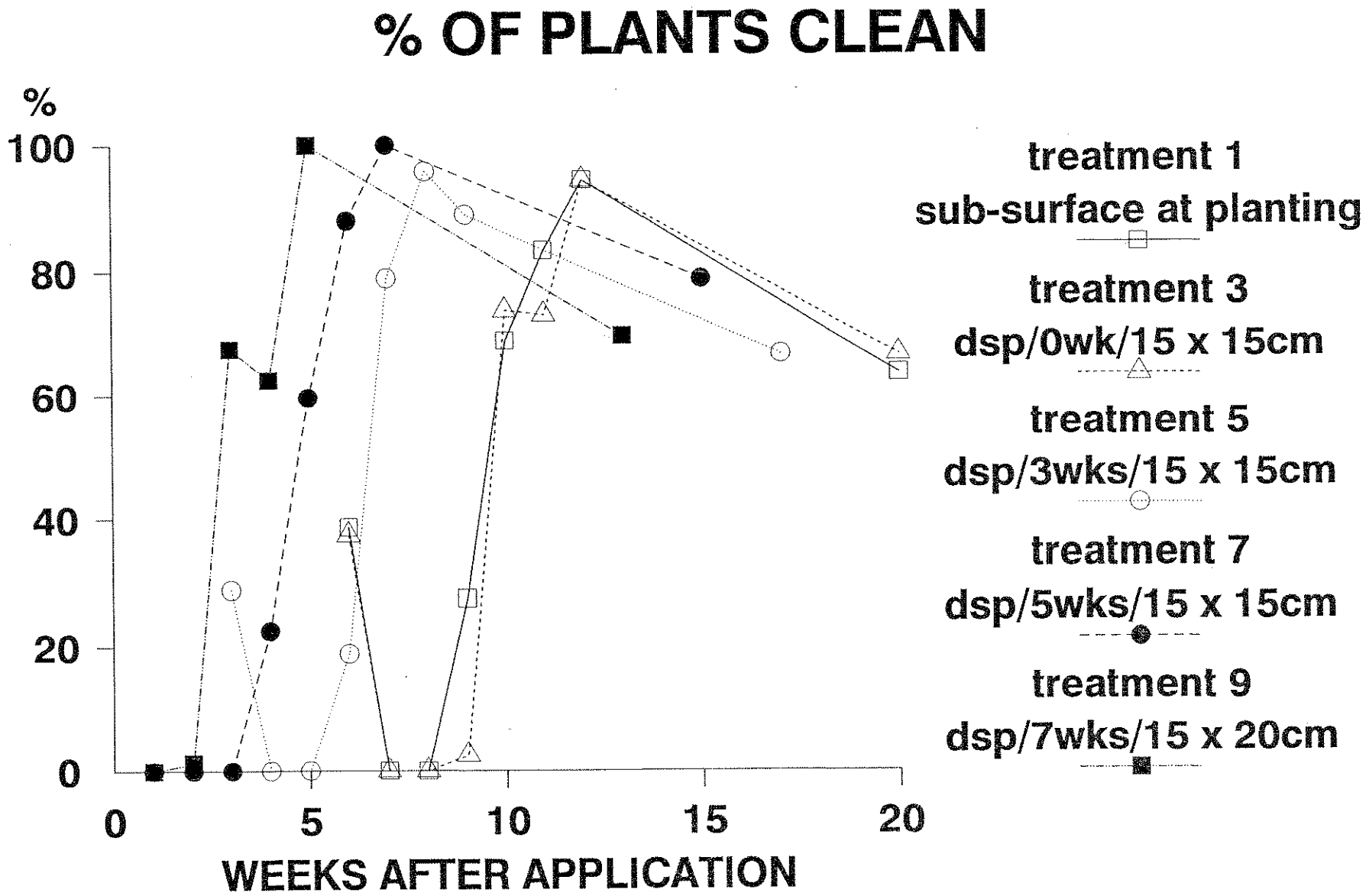

FIGURE 38: Proportions of aphid-free Brussels sprouts plants at intervals after application of disulfoton FE.10 as a sub-surface band or as a deep side-placement (15 x 15, 15 x 20 cm)

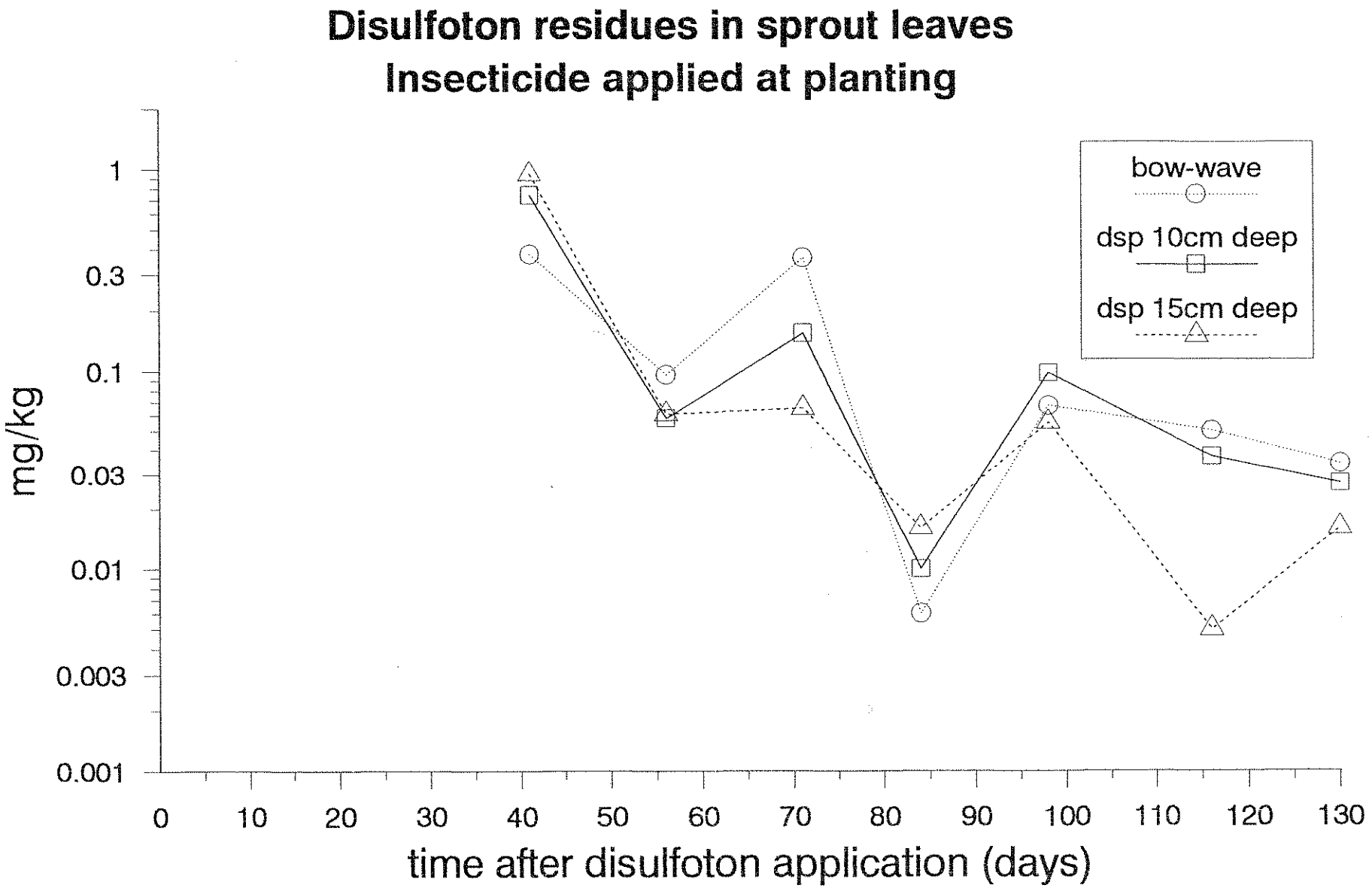

FIGURE 39: Disulfoton residue concentrations in sprout leaves following application at planting time

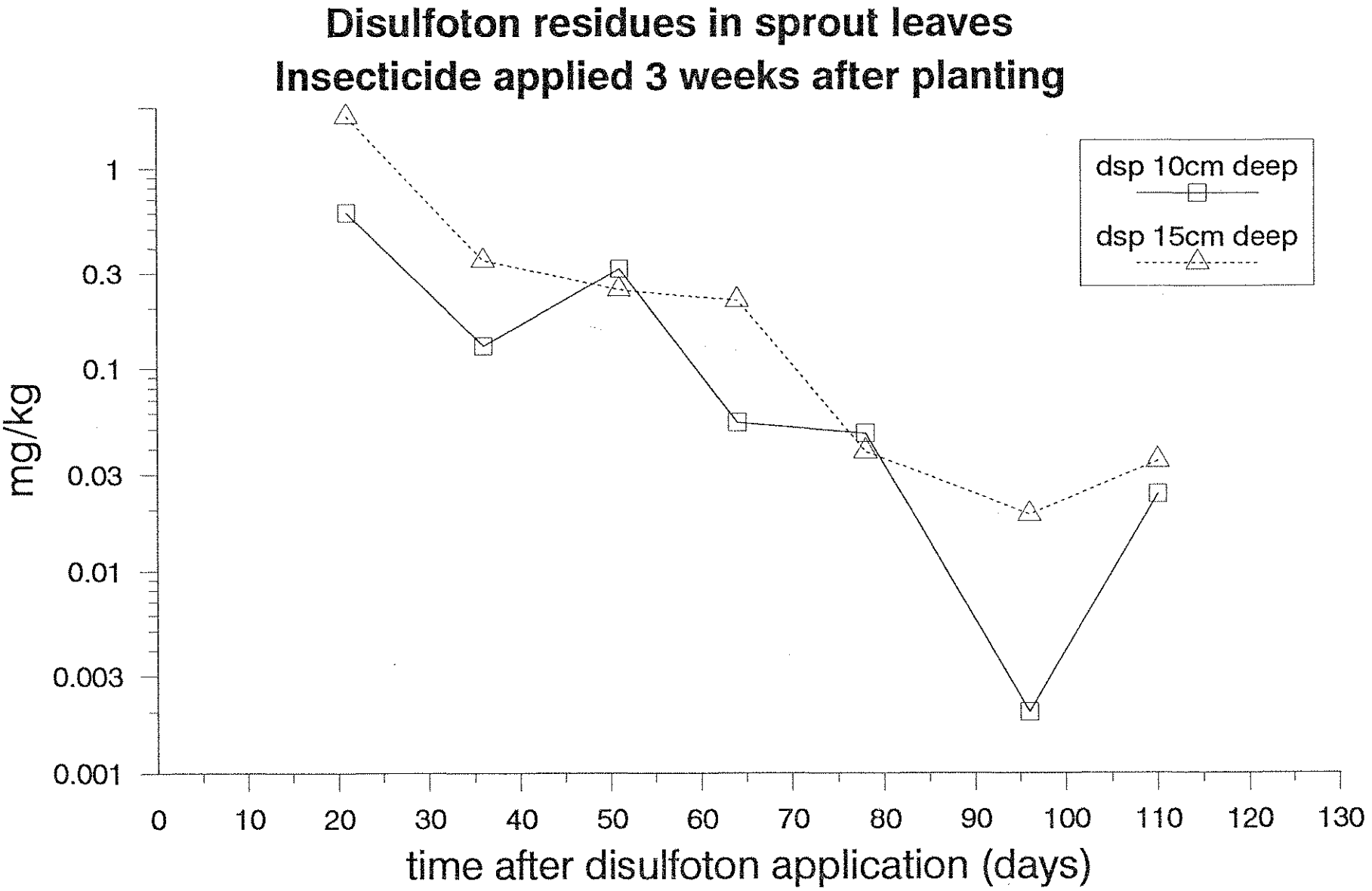

FIGURE 40: Disulfoton residue concentrations in sprout leaves following deep side-placement 3 weeks after planting

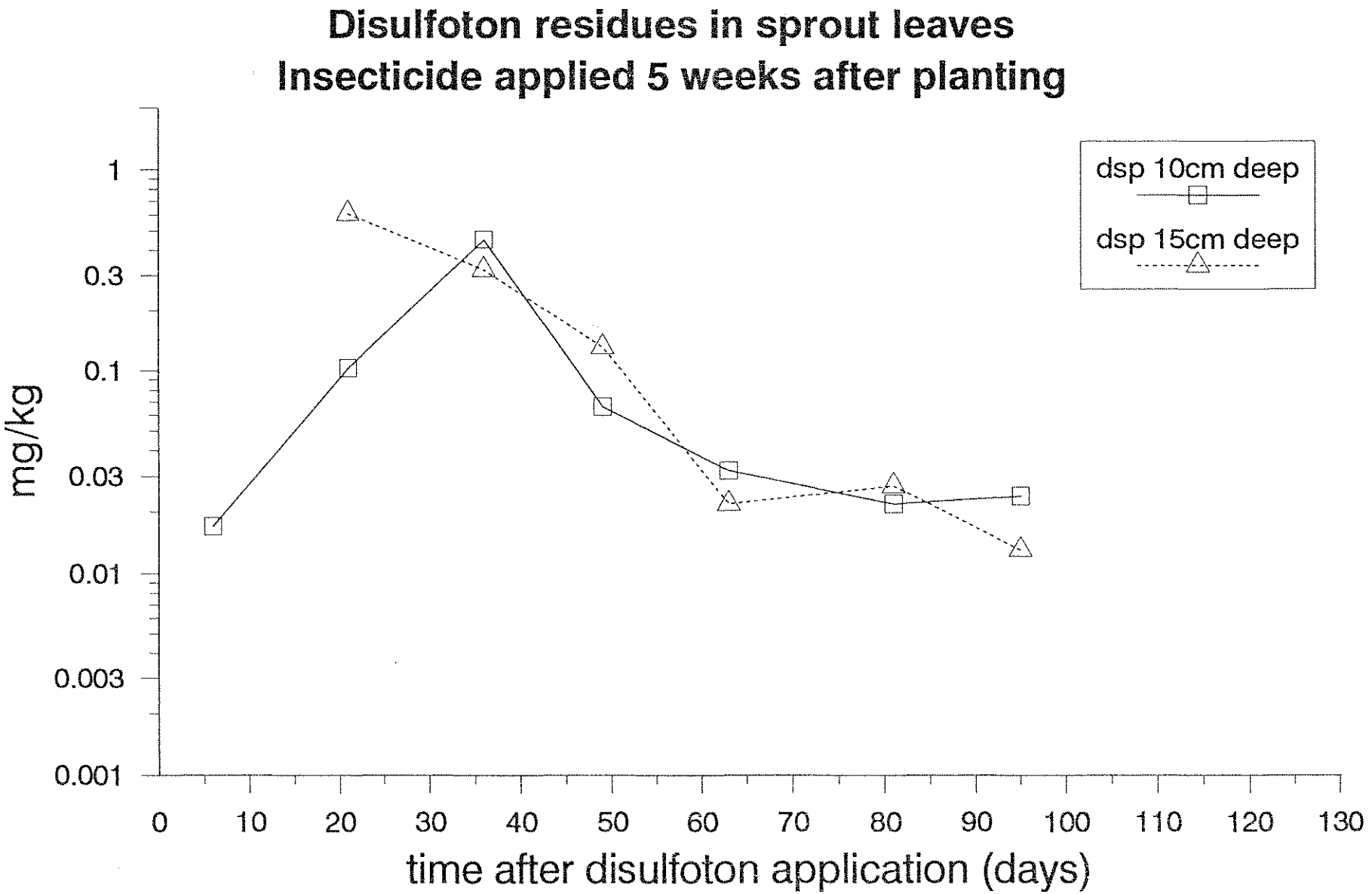

FIGURE 41: Disulfoton residue concentrations in sprout leaves following deep side-placement 5 weeks after planting

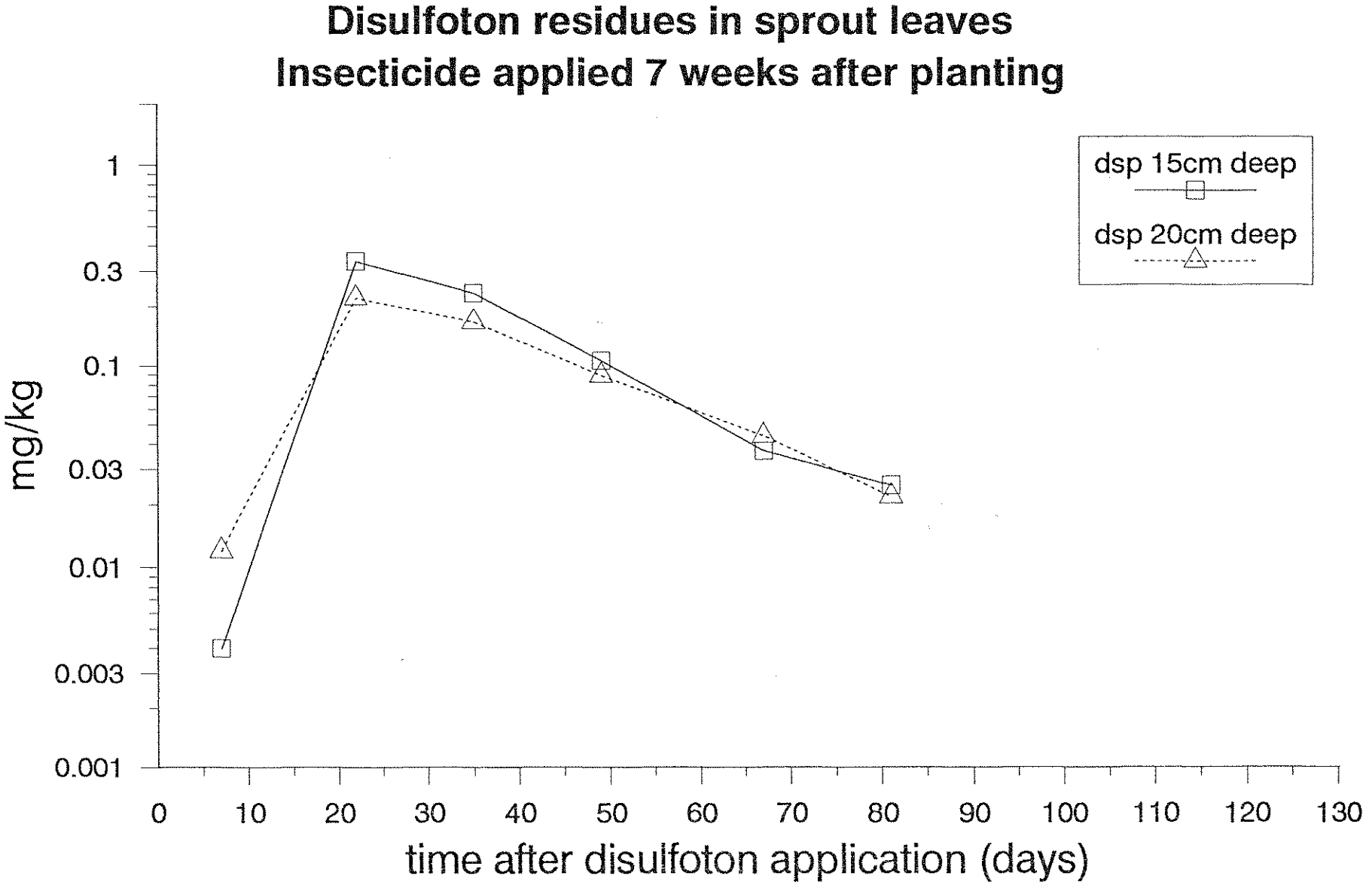

FIGURE 42: Disulfoton residue concentrations in sprout leaves following deep side-placement 7 weeks after planting

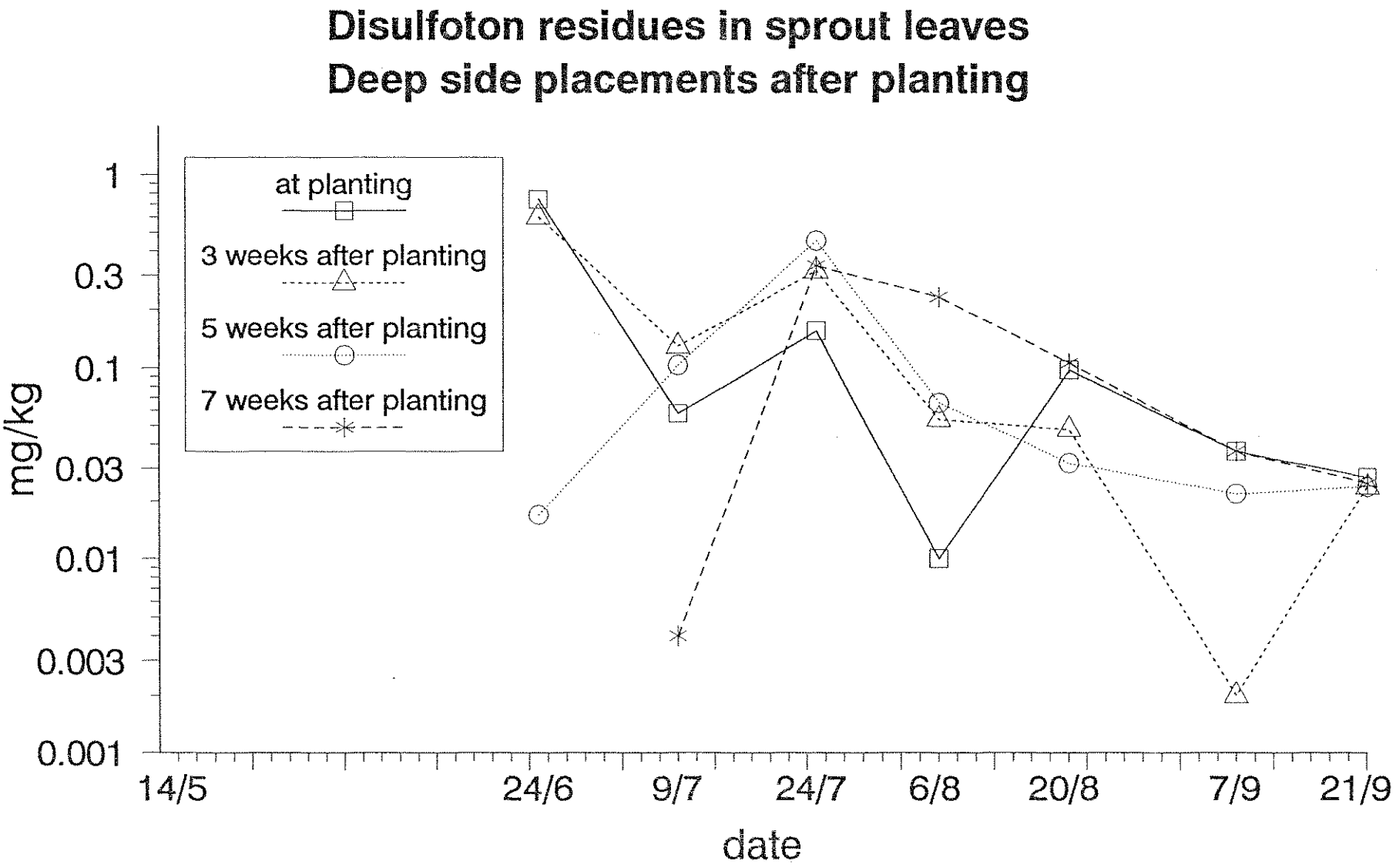

FIGURE 43: Disulfoton residue concentrations in sprout leaves following the shallower (i.e. 10 cm, then 15 cm) placement 0-7 weeks after planting

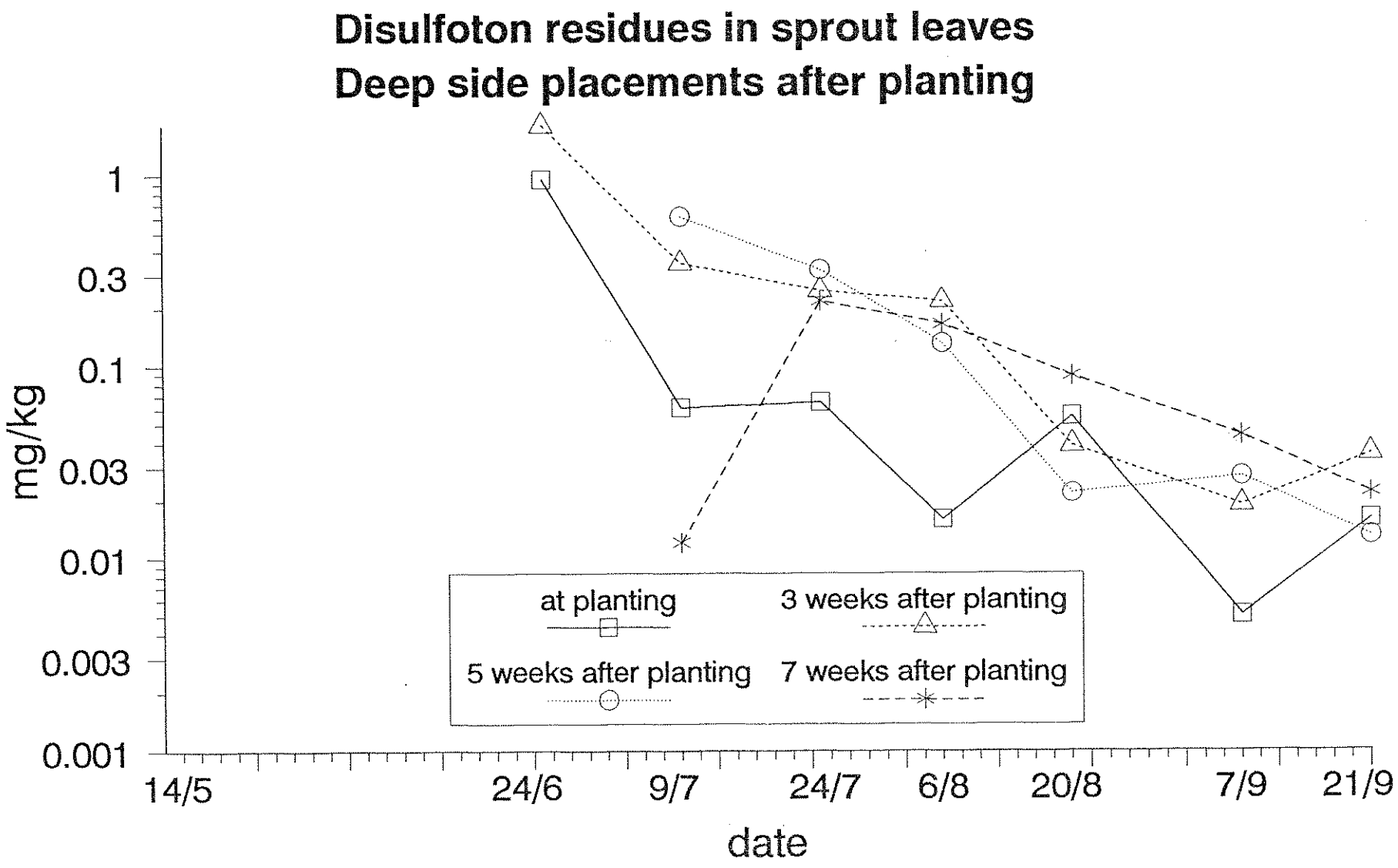

FIGURE 44: Disulfoton residue concentrations in sprout leaves following the deeper (i.e. 15 cm, then 20 cm) placement 0-7 weeks after planting

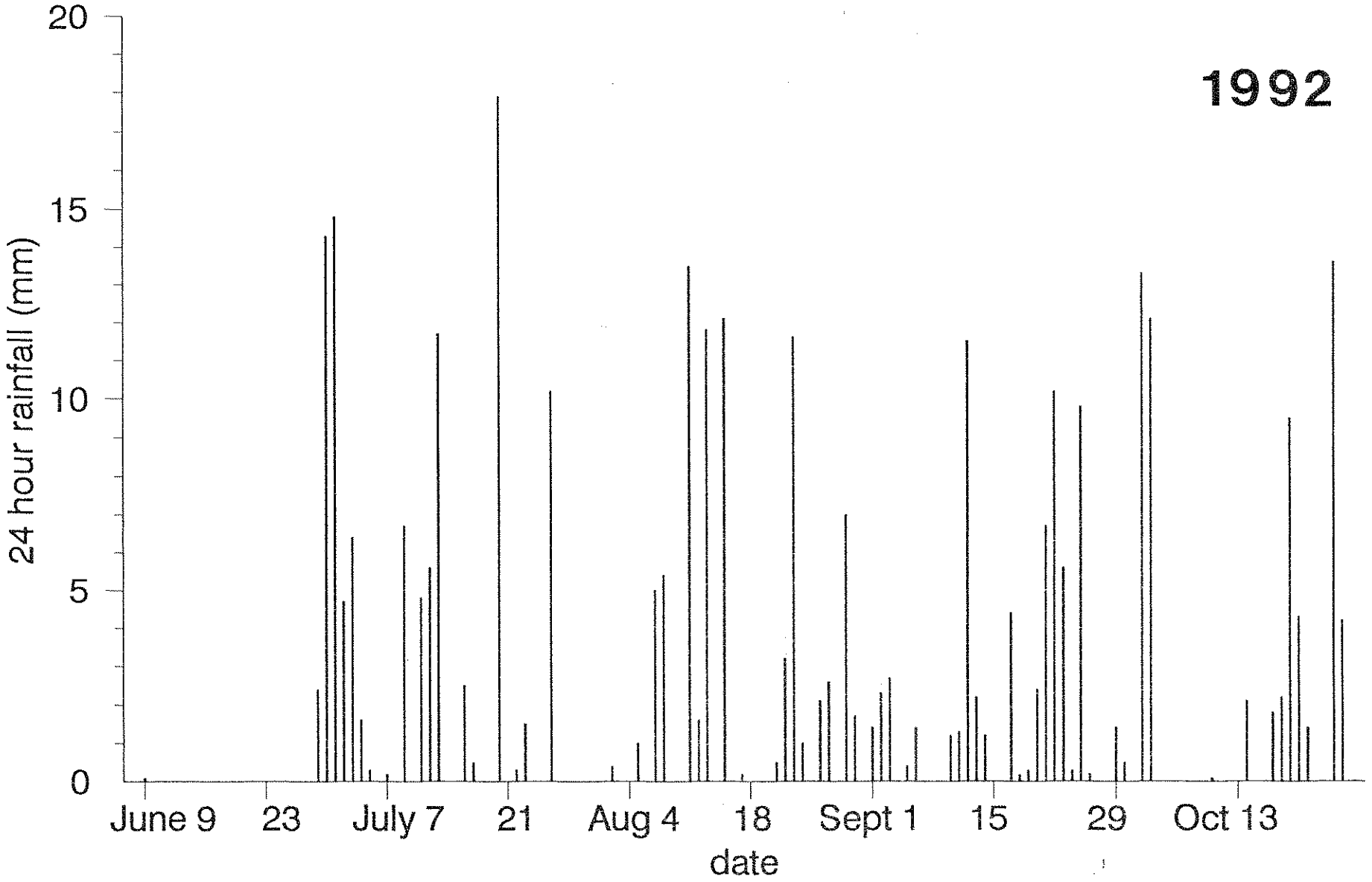

FIGURE 45: Rainfall during June - October 1992

FV42 - RESIDUE ANALYSIS RECORD

Year	Expt	Crop	Residues measured	No. of samples analysed
1990	A. 90114	Brussels sprouts	disulfoton	4
			disulfoton + demeton-S-methyl	2
	B. 90115	Lettuce	demeton-S-methyl	96
	C. 90116	Spring cabbage	disulfoton	4
1991	D. 91032	Lettuce	demeton-S-methyl	235
	E. 91035	Brussels sprouts	disulfoton	4
			disulfoton + demeton-S-methyl	8
	F. 91037	Cauliflower	disulfoton	8
	G. 91096	Brussels sprouts	demeton-S-methyl	16
1992	H. 92052	Brussels sprouts	disulfoton	211

Total number of analyses = 588