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**EFFECT OF EARLY PLANTING ON THE TOLERANCE OF POTATO CV. EHUD
TO ATTACK BY *GLOBODERA ROSTOCHIENSIS* PATHOTYPE RO 1
AND *G. PALLIDA* PATHOTYPE PA 3.**

by
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Summary. Planting potato cv. Ehud (highly resistant to *Globodera rostochiensis* pathotype Ro 1 but susceptible to *G. pallida* pathotype Pa 3) in the end of February in a cold glasshouse resulted in stunted growth and shortening of the growing period (short day habitus). There was a strong reduction of the tolerance to pathotype Ro 1 of *G. rostochiensis* and a somewhat smaller one to pathotype Pa 3 of *G. pallida* compared to the respective tolerances of cv. Ehud when planted in April.

To investigate the effect of attack by potato cyst nematodes *Globodera rostochiensis* (Woll.) pathotype Ro 1 and *G. pallida* (Stone) pathotype Pa 3 on the growth and weight of potato (*Solanum tuberosum* L.) plants during the first weeks of growth, cv. Ehud (highly resistant against the first, susceptible to the latter pathotype) was planted on 24 February 1982. The early planting (short days) induced the plants to assume a short day habitus, with an early start of tuber growth and tuber to total weight ratios equal to those at about half the age of conventionally grown plants. The early planting also caused a decrease of the tolerance to the attack by the potato cyst nematodes. The differences with normal plants are described.

Materials and methods

The experiment was done in cylindrical pots 10 cm wide and 20 cm deep containing 2 kg of a mixture of silver sand (60%), crushed ceramic material ("red coat") (30%) and clay powder

(10%) to which 0.2 g mixed fertiliser (NPK 12:10:18) and 80 ml of a modified Knopp's nutrient solution were added. The pots were inoculated with eggs of *G. rostochiensis* pathotype Ro 1 and of *G. pallida* pathotype Pa 3 by injecting 4 ml of egg suspension at the required egg density into each of four equally distributed 2 mm wide channels from about 5 cm from the bottom of the pot to the soil surface. The egg densities were 0 and 0.2×2^x for pathotype Ro 1 and 0.22×2^x for pathotype Pa 3, both with $x =$ whole numbers 0 to 10. A cylindrical piece of tuber of cv. Ehud, 1 cm diameter and 1.5 cm long with one sprout was planted at 5 cm depth in each pot on February 24. The soil was covered with a piece of plastic with a number of holes to allow emergence of the sprout and for watering. Water was then added to the pots to raise the moisture content to 15% of the dry soil weight. There were fifteen replications per nematode density. Dry tuber and total weights and water consumption per day per unit weight of plant were determined at three, five and seven weeks after planting but only at seven

weeks after planting were the differences between the effects of the different nematode densities sufficiently large to warrant a detailed analysis and discussion.

The results are compared with those of a second experiment with ranges of egg densities of both potato cyst nematode pathotypes on cv. Ehdud planted on 7 April and harvested at the end of the second week of August, except for a number of plants with dying haulms at large initial egg densities, that were harvested from the third week of July. This experiment was done in 20 cm deep pots, filled with 10 kg of the same potting mixture as in the first experiment. There were again five replicates per nematode density and pathotype. The pots were inoculated by injecting nematode suspensions distributed from top to bottom into 20 vertical channels. Egg densities were 0 and 0.25×2^x per g soil with x = whole numbers from 0 to 10 for pathotype Ro 1 and from 1 to 11 for pathotype Pa 3. Further treatment of the pots was as described of the two kg pots.

Results

Seven weeks after planting on 24 February the average haulm length of plants without nematodes was 27 cm and average total dry weight 4.3 g/plant. The tuber to total weight (dry matter) ratio was already 0.53. The average total dry weight of seven week old plants, planted on 7 April, which had grown at a higher temperature during the first weeks after planting, was 6.5 g and average haulm length 80 cm. The plants had no tubers yet. A tuber to total weight (dry matter) ratio of 0.53 was only reached 15 weeks after planting at a haulm length of 200 cm and a total dry weight of 49 g/plant. The very early planting and, consequent short days, induced a short day habitus with very early initiation of tuber formation.

No nematodes had penetrated into the roots of the plants at three weeks after planting and

there were no differences in dry weight between the plants at the different initial egg densities. Apparently, the low temperature in the glasshouse had kept the nematodes inactive. There was a distinct reduction of haulm weight by the nematodes five weeks after planting. It was larger with pathotype Ro 1 than with pathotype Pa 3, but the differences were too small compared to the plant to plant variation to estimate tolerance limits. Tuber initiation had not yet started.

Relative total plant and tuber weights, tuber to total weight ratios, dry matter content of the haulms at the end of the experiment seven weeks after planting and relative water consumption per unit total plant weight during the last week before the end of the experiment are given in Fig. 1. Curves according to the equation $y = m + (1 - m) 0.95^{P/T-1}$ for $P > T$ and $y = 1$ for $P > T$ in which y = the ratio between dry weight at nematode density P and the estimated average weight at $P < T$, T = the nematode density up to which plant weight is not affected and m = this ratio at very large P (Seinhorst, 1986), fitted well to the relations between small and medium nematode densities of both pathotypes and total dry plant weights (Fig. 1A). T was estimated to have been 0.6 eggs/g soil and $m = 0.75$ for pathotype Pa 3 and $T = 0.3$ eggs/g soil and $m = 0.55$ for pathotype Ro 1. At initially more than about 30 eggs/g soil plant weights were considerably less than according to these curves. There was a negative correlation between water consumption/g plant during the last week of the experiment and initial egg densities at > 15 eggs/g soil and 4 eggs/g soil of both pathotypes, respectively, and a positive correlation between dry matter content of haulms and the egg densities. Contrary to pathotype Pa 3 pathotype Ro 1 increased the tuber to total weight ratio at 30 and more eggs/g soil. There may have been a slight decrease of tuber to total weight ratios between 2 and 25 eggs/g soil of both pathotypes. The large egg densities of pathotype Pa 3 reduced water consumption

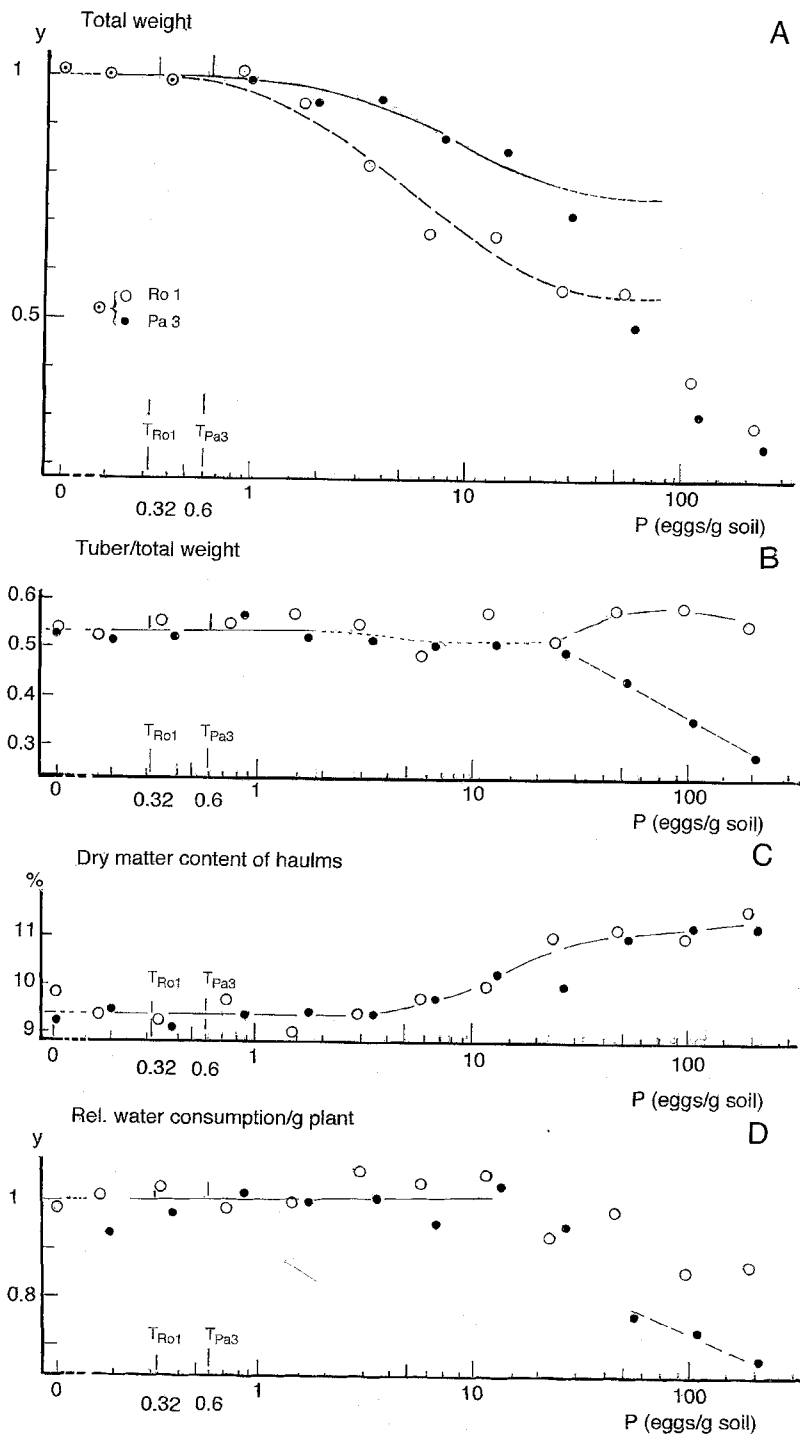


Fig. 1 - The relation at seven weeks after planting of cv. Ehud planted 24 February between initial egg density (P) of pathotypes Ro 1 and Pa 3 and: A, Relative total dry plant weights (y). The curves are according to the equation $y = m + (1 - m) 0.95^{P/T-1}$ for $P > T$ and $y = 1$ for $P < T$ with $y = 1$ for 4.4 g dry total weight per plant in a 2 l pot; B, tuber to total plant weight (dry matter); C, dry matter content of haulms; D, relative water consumption per unit total dry plant weight during the last week before the end of the experiment.

per unit dry plant weight more than those of pathotype Ro 1.

The relations between initial egg density of pathotypes Ro 1 and Pa 3 and relative total plant weight of cv. Ehud, planted in April at 14.5 to 18 weeks after planting are given in Fig. 2. Tolerance limits T were 3.3 and 1.8 eggs/g soil for pathotypes Ro 1 and Pa 3, respectively and values of m 0.7 and 0.48. Again relative total dry weights were much smaller than according to eq. (1) with these parameters at the largest initial egg densities. Other characteristics of the plants at different initial egg densities will be discussed elsewhere.

Discussion and conclusions

The values of T for the curves according to eq. (1) in Fig. 1A (planting in the end of February) are considerably smaller than those according to Fig. 2 (planting in April). The value of T for pathotype Pa 3 on cv. Ehud, planted on April 7 is the same as that derived from field observations on pathotype Ro 1 on cvs Bintje and Mentor (Seinhorst, 1982): 1.8 eggs/g soil. A value of T of 1.7 for *G. pallida* on cv. Sieglinde and *G. rostochiensis* on cv. Tonda di Berlino in micro plots in three localities in Italy was derived from data in Greco *et al.* (1982) and for

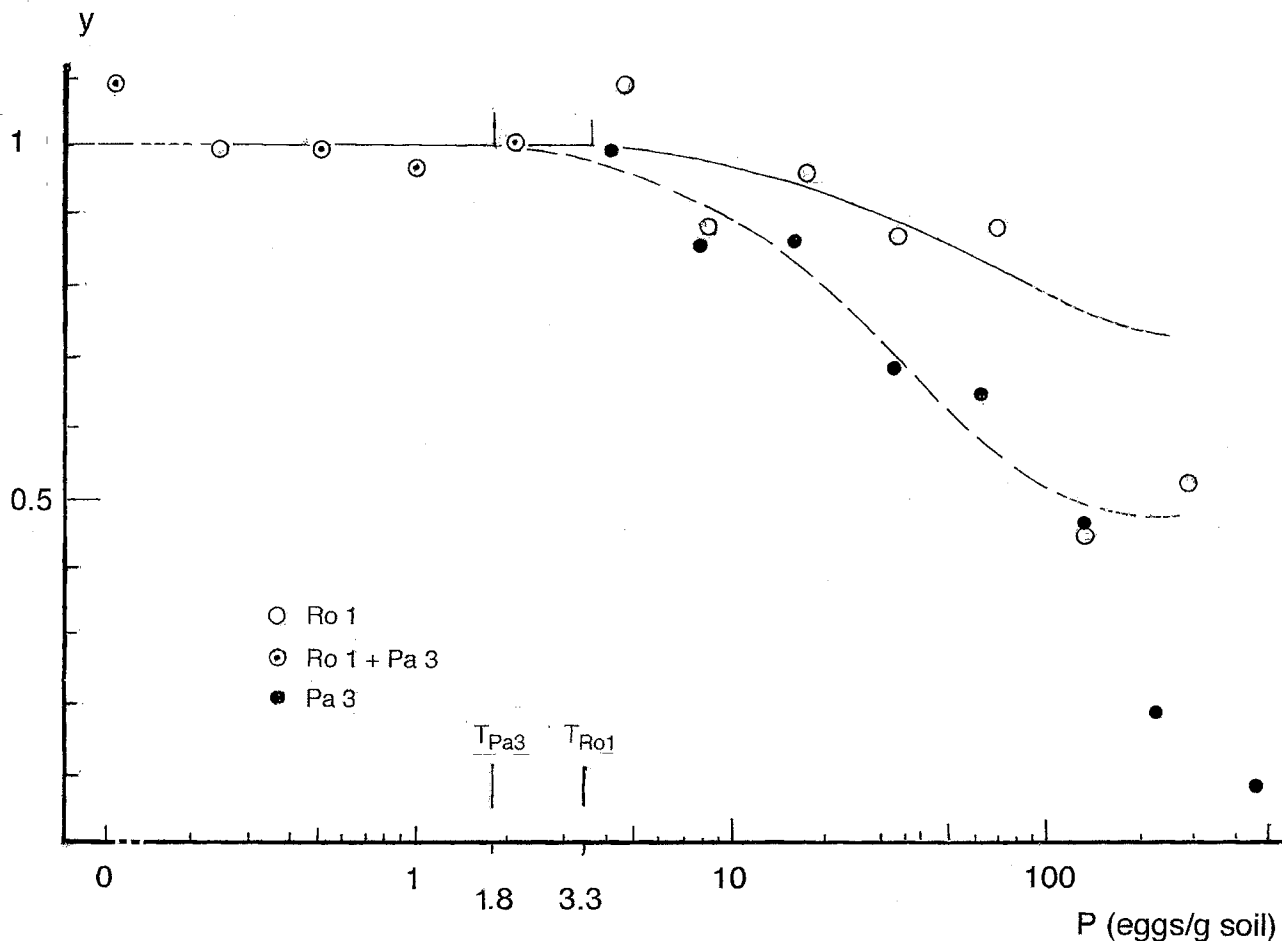


Fig. 2 - The relation between initial egg densities of pathotypes Ro 1 and Pa 3 and final total dry weight of cv Ehud planted 7 April. The curves are according to the equation: $y = m + (1 - m) 0.95^{P/T-1}$ for $P > T$ and $y = 1$ for $P < T$ and with $y = 1$ for 50.8 g dry weight per plant in a 10 l pot.

potatoes planted in spring and mid-summer in Central Chile from data in Greco and Moreno (1992). A value of 1.8 eggs/g soil was also derived from unpublished data from pot experiments with pathotypes Ro 1, Ro 3 and Pa 3 on several potato cultivars in three pot experiments planted in April at Wageningen, the Netherlands.

The early planting (daylength on 24 February at Wageningen 10 hrs 20 min.) induced cv. Ehud to assume the short day habitus and, apparently, decreased its tolerance to both pathotypes but, despite the high resistance, that to pathotype Ro 1 ($T = 0.32$ eggs/g soil) more than that to pathotype Pa 3 ($T = 0.6$ eggs/g soil). A similar reduction of the tolerance limit of cv. Ultimatus planted in mid-winter for *G. rostochiensis* but without induction of a short day habitus was found by Greco and Moreno (1992) in central Chile. However, planting on 24 February in Bari (daylength 11 hrs) neither induced a short day habitus in cv. Sieglinde nor reduced its tolerance. On the other hand, Been and Schomaker (1986) found a considerable increase of the tolerance of cv. Irene to pathotype Pa 3 with a short day regime with constant daylength (14 hrs), 20 °C during the day and 15 °C during the night. There are no indications of the causes of these difference in reaction of different potato cultivars to differences in day length (possibly in combination with differences in temperature).

The large values of m in Fig. 1A (especially that for pathotype Pa 3) are probably due to the late start of nematode activity (more than three weeks after planting) provided that it would have been small if nematode attack had started immediately after planting. However, the effect of the delay is considerably smaller than in oats with oat cyst nematode (Seinhorst, 1995).

Plant weights were reduced more than according to eq. (1) with values of T and m fitting to plant weights at small and medium nematode densities at initial egg densities of both pathotype of > 30 eggs/g soil or possibly a slightly

smaller density for pathotype Pa 3. For planting on 7 April the egg densities were 100 eggs/g soil for pathotype Pa 3 and 80 eggs/g soil for pathotype Ro 1. This greater reduction of the total dry weight of the plants at large initial egg densities is associated with a negative correlation of water consumption per unit total dry weight and a positive one of dry matter content of the haulms with initial egg density. Therefore, it has the characteristics of growth reduction by the "second mechanism of growth reduction" of Seinhorst (1981). Dry matter content of the haulms at the end of the experiment is positively correlated with initial egg density of both pathotypes at > 5 eggs/g soil and, therefore, from a much smaller initial egg density upward than the other effects of the "second mechanism of growth reduction".

The tuber weight to total weight ratio at initial egg densities > 30 eggs/g soil was positively correlated with initial egg density of pathotype Ro 1 and negatively with that of pathotype Pa 3. This suggests that at densities of pathotype Pa 3 > 30 eggs/g soil either the start of tuber growth was considerably delayed or haulm growth was maintained at the cost of tuber growth. On the contrary, pathotype Ro 1 probably advanced the start of tuber growth compared to that at egg densities < 30 eggs/g soil., resulting in larger tuber to total weight ratios than at smaller egg densities. There apparently is a qualitative difference in the ways pathotypes Ro 1 and Pa 3 affect the growth of potato plants at large initial egg densities.

The results of the experiment reported here, and other data (Been and Schomaker, 1986; Greco and Moreno, 1992) indicate that exposure of potato plants to short day regimes can have a profound effect on tolerance to cyst nematodes, peculiarly enough either increasing (Been and Schomaker, 1986) or decreasing it (Greco and Moreno, 1992, and this paper). On the other hand, planting of cv. Sieglinde on 20 February at Bari, southern Italy (Greco *et al.*, 1982) and, therefore, at about the same date but

TABLE I - Relation between planting time (day-length), tolerance limit and plant habitus.

Planting time	Country	Daylength (hours)	Author(s)	T eggs/g soil	Plant habitus
Spring	Netherlands	> 12 hs	Seinhorst (1982)	1.7-1.8	normal
	South Italy		Greco <i>et al.</i> (1982)		
	Central Chile		Greco and Moreno (1992)		
Mid-winter	Central Chile	<12hs	Greco and Moreno (1992)	<1	normal
Late winter (20 February)	South Italy	11 hs	Greco <i>et al.</i> (1982)	1.7	normal
Late winter (24 February)	Netherlands	10.3 hs	This publication	<1	stunted and early tuber formation
Late summer	Central Chile	>12 hs	Greco and Moreno (1992)	1.7	normal
	Growth room 20,000 lux	14 hs	Been and Schomaker (1986)	>30	stunted and early tuber formation

at slightly longer days during early development than in the present experiment, did not cause a deviation of its tolerance to pathotype Pa 3 from that of other susceptible cultivars planted later ($T = 1.7$ eggs/g soil).

The effects of daylength on the habitus of potato plants and on their tolerance to growth and yield reduction by potato cyst nematode according to the results of different experiments are summarised in Table I.

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