

A Study on Post-peak Flowering Shoot Manipulation for Seed Production of *Lotus corniculatus* L.¹

Qingfeng Li² and Murray J. Hill³

ABSTRACT

Seed yield in *Lotus corniculatus* L. is primarily determined by the number of inflorescences and the number of fertile shoots. Shoot manipulation is, therefore, one possible approach to increasing seed yield in this species. While a large population of fertile shoots present at peak flowering is a prerequisite for high seed yield, the continued production of vegetative shoots after peak flowering may impose severe competition for assimilate with flowers and seeds, and, therefore, might constrain levels of seed production. This study investigated the effects of two plant growth regulating chemicals (Nortron and Fatol Super) on shoot growth and development and seed production of *Lotus corniculatus*. These two chemicals were applied at different stages of plant development, and their effects on plant growth, branching behavior, seed yield components and final seed yield were examined at two sites using spaced plants and a sward crop. The results indicate different responses on seed yield from chemical manipulation of plant growth, depending on the time of application and on whether chemicals were applied to spaced plants or swards.

Additional key words: birdsfoot trefoil, Fatol Super, Nortron, seed production, yield components.

INTRODUCTION

Poor seed production in *Lotus corniculatus* L. is considered to be a major factor limiting its more widespread use as an important pasture legume. Seed yield in this species depends mainly on the number of shoots, and consequently the number of inflorescences produced over the period of most intensive flowering (Li and Hill, 1989). Manipulating plant structure and, in particular, shoot structure and population was considered to be one possible approach to improving seed yield in this species. Two major groups of shoots are likely to affect seed formation potential and ultimate seed yields in *Lotus cor-*

niculatus. The presence of a large number of shoots at flowering is obviously important, since the number of fertile shoots and subsequently the number of inflorescences are well correlated with final seed yields (Li and Hill, 1989). Perhaps as important, however, is the potentially negative effect of the continued production of new shoots after peak flowering. This post-flowering 'flush' of new shoots appears to provide an intensely competitive 'sink' for assimilate and may, therefore, be considered to be 'undesirable' on plants being grown for seed production. This is particularly likely in *Lotus corniculatus* since this species has a 'continuous growth' habit in which new shoots continue to emerge during and following peak flowering. Such new shoots represent a considerable percentage in the total shoot population, but are of little or no value in contributing to the current year's seed harvest since they emerge too late for flowering due to the onset of non-inductive daylength (Li and Hill, 1989).

The present study investigated the possibility of controlling the emergence and growth of post-peak flowering shoots by the application of plant growth regulating chemicals. Two different chemicals were examined to assess their value in preventing or suppressing the formation of late shoots.

Nortron (Ethofumesate) is a herbicide which inhibits mitosis in actively growing young tissues. The initiation of new shoot primordia inevitably involves cell division while the growth of older shoots occurs mainly through cell enlargement. This chemical was selected for this experiment in an attempt to prevent late new shoot emergence without harming the growth of already formed older shoots.

Fatol Super (a fatty alcohol compound) is a 'sucker killer' which has been successfully used in tobacco crops for controlling lateral buds (suckers) (Steffens and Selfmann, 1982; O'Connor, 1984). Since this chemical is known to be particularly injurious to young plant tissues with little or no harmful effects on old tissues, it was selected for use in this study in an attempt to destroy already formed late shoots.

MATERIALS AND METHODS

Experiments were carried out at two sites near

¹A contribution from the Seed Technology Centre, Massey University, Palmerston North, New Zealand. Received for publication 20 March 1989.

²Research Fellow, Miss E.L. Hellaby Grassland Memorial Trust, Seed Technology Centre, Massey University, Palmerston North, New Zealand

³Director, Seed Technology Centre, Massey University, Palmerston North, New Zealand

Palmerston North, New Zealand (40°S, 170°E). The first site, at the Seed Technology Center (STC), Massey University, involved spaced plants with a row width of 80 cm and intra-row spacing of 60 cm. The second site, at the Department of Scientific and Industrial Research's experimental farm at Aorangi, involved a crop grown in 60 cm rows with 64 plants m⁻¹ row. At both sites no fertilizer or irrigation was applied during the experimental period. Management and treatment details are presented in Table 1. All treatments at each site were replicated

Table 1. Management and experimental details for Seed Technology Center (Site 1) and Aorangi (Site 2).

	Site 1	Site 2
Soil type	Tokomaru silt loam.	Kairanga silt loam
Replicate size	3 x 5 m ² plot	Nine plants per row
Sowing rate	Spaced plants	1.05 kg ha ⁻¹
Sowing date	9 May 1987	3 April 1987
Weed control	'Roundup', preplanting 'Paraquat', 29 July	'Trifluralin', preplanting '2,4-DB', 2 May
Grazing	Sheep, 23-25 Sept.	Nil
Nortron application		
Date	25 Oct., 15 Nov., 5 Dec.	27 Oct., 17 Nov., 7 Dec.
Rate	1% solution	2.5% solution
Fatol application		
Date	2 Nov., 22 Nov., 12 Dec., 2 Jan., 2 Jan. ¹	6 Nov., 26 Nov., 21 Dec., 21 Dec. ¹
Rate	3% solution	3% solution
Harvest date	2 Feb. to 9 Feb.	22 Feb. (all treatments)

¹1.5% rate, double volume of application (Fatol 4 2X)

three times in a randomized block design. Inflorescence numbers were assessed at five-day intervals by counting open flowers on nine plants for each replicate at site 1 and by counting open flowers with a 1 m² permanent quadrat for each replicate at the Aorangi site (site 2). Number of florets per inflorescence was assessed at 10-day intervals by counting floret numbers in 30 inflorescences randomly selected from each replicate at site 1. At site 2, the number of florets was assessed once at the post-peak flowering stage on 15 January 1988. Number of pods per inflorescence, number of seeds per pod, thousand-seed weight and seed yield were recorded following hand harvesting of 5 spaced plants (site 1) or fol-

lowing the harvesting of all plants within a 0.6 m² quadrat (site 2). Seed yields were expressed at 9.9-11.6% moisture content and 8.2-8.7% moisture content for sites 1 and 2 respectively.

RESULTS

1. Effects on plant growth and development: Nortron had a strong inhibitory effect on the emergence of new shoots arising from the crown. Nortron-treated plants showed disrupted growth and development in that the production of crown shoots was much reduced following application. Already formed shoots also showed injury symptoms which were readily seen as a twisting or folding of the shoot apex and floral buds. Leaf tissue became slightly yellow and flower corollas occasionally showed a purple-red coloration. As well as inhibiting shoot growth and development, Nortron also had an injurious 'herbicide' distorting effect on flowers.

The effect of Fatol Super was seen by the appearance of 'burning' symptoms 1-2 days after application. Young shoots appeared to be particularly sensitive to the chemical. Leaves on young shoots wilted, and finally the entire shoot etiolated and died. Older shoots were less sensitive to Fatol Super and often showed no or only slightly injurious symptoms. Flowers showed no visible symptoms of injury. This chemical temporarily controlled the emergence and growth of young shoots. However, since Fatol Super is a contact 'sucker killer', its effect is quick but short lived. Several days after treatment, new shoots emerged from the crown on plants which had been previously treated. The use of this chemical was effective in killing young vegetative shoots present at the time of application. However, Fatol Super was of only limited value in controlling regrowth of new shoots. Long term control of late shoots would require repeat applications of the chemical.

2. Effects on flowering pattern: At both sites the number of inflorescences produced in Nortron treatments was generally lower than in untreated plants and varied widely, particularly at site 1. Early treatment (late October) had less harmful effects on flowering, probably because application was more remote from the time of intensive flowering (early January), allowing plants a longer period of recovery growth following injury. Later applications (mid November and early December) showed very obvious effects on flowering, the number of inflorescences dropping significantly following chemical application (Figure 1a).

At site 2 all three Nortron treatments reduced the number of inflorescences produced during the early flowering season. However, plants in the first two treatments eventually recovered from injury and at peak flowering the number of inflorescences in these two treatments was similar to the untreated control (Figure 1b).

STC SITE

- spaced plants

AORANGI SITE

- sward plants

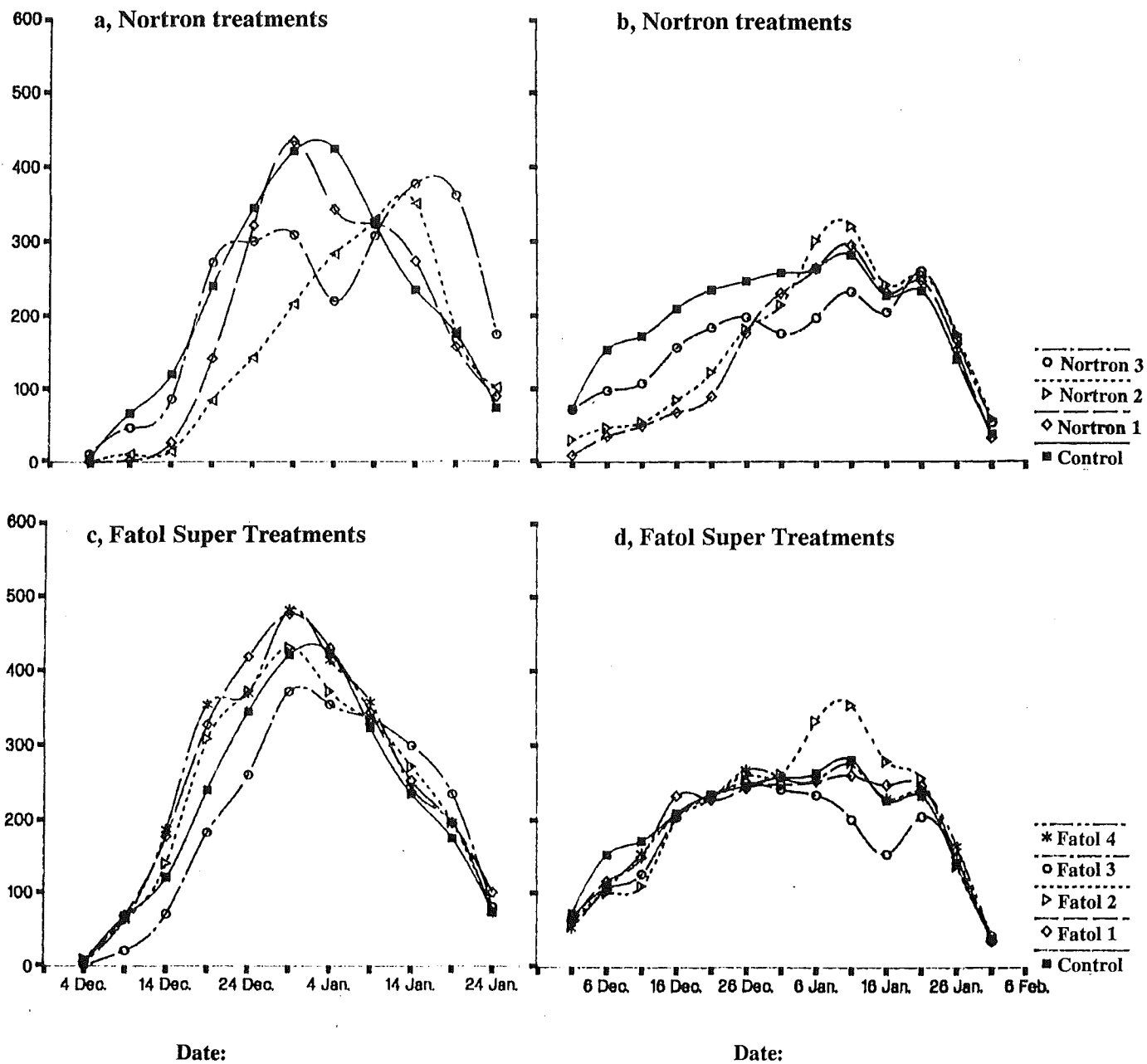


Figure 1. Flowering patterns in *Lotus corniculatus*

As already mentioned, Fatol treatments had no long term effect in controlling the continuous emergence of new shoots, although treatment did not harm reproductive structures on old shoots. Consequently, flowering pattern was not greatly influenced by Fatol Super treatment (particularly the two early treatments). At site 1, treatments 1, 2 and 4 slightly increased inflorescence numbers at peak flowering, but treatment 3 reduced the number of inflorescences (Figure 1c). At site 2, treatment 3 also reduced the number of inflorescences present at post-peak flowering. Treatment 2 increased the number of inflorescences, and the remaining two treatments showed no obvious effects on flowering pattern (Figure 1d).

3. Effects on yield components: At site 1, number of florets and number of pods per inflorescence were assessed on four treatments (Nortron 2, 3 and Fatol 2, 3). Nortron treatments reduced and Fatol Super increased the floret bearing ability of inflorescences. Pod numbers reacted similarly, bearing about one pod less than the number of florets per inflorescence (Table 2). Seed numbers per pod and thousand seed weight showed no significant differences between the chemical treatments and the untreated control.

Table 2. Seed yield components at site 1

Treatment	Inflorescence		Florets inflor. ⁻¹	Pods inflor. ⁻¹	1000- Seeds pod ⁻¹	seed weight
	Total	20 days ⁺				
Control	2416	1510	6.00	4.58	13.8	1.35
Nortron 1	2109	1420	na	na	13.8	1.30
Nortron 2	1706	1177	5.62*	4.12*	15.1	1.37
Nortron 3	2460	1210	5.49*	4.16*	13.3	1.54
Fatol 1	2793	1667	na	na	11.6	1.32
Fatol 2	2571	1507	6.36*	4.94*	12.9	1.36
Fatol 3	2209	1321	6.38*	4.77*	14.2	1.27
Fatol 4	2739	1622	na	na	12.3	1.37
Fatol 4 2X	na	na	na	na	13.1	1.25

* - Significantly different from the control at P=0.05

+ - within 20 days of most intensive flowering

na - data not available

Although only number of florets per inflorescence was assessed at site 2 (15 December 1987), there was no significant difference between the control and any of the chemical treatments (Figure 3).

4. Effects on seed yield and seed quality: Seed yield at site 1 was expressed in three different ways: actual yield (seed yield actually harvested from the field); potential yield (yield calculated from the yield components

including all inflorescences produced by the plants); and calculated yield (yield calculated using only those inflorescences produced over the 20 days of most intensive flowering).

Seed yield data at both sites are presented in Table 3. Calculated seed yield and potential seed yield were both lower than in the control for Nortron treatments at the site 1. Actual harvested seed yields, however, were not significantly different between the treatments and the control. In the Fatol Super treatments, application time had an effect. Early applications (the first three) had no effect in improving seed yield. Late applications (Fatol 4) and the low rate of large volume application (Fatol 4 2X) had a beneficial effect in enhancing actual seed yield.

Table 3. Comparative seed yields at site 2.

Treatment	Yield (actual) (kg ha ⁻¹)	Yield (g per 5 plants)		
		Actual	Calculated	Potential
Control	457	127	129	206
Nortron 1	654*	127	na	na
Nortron 2	500	126	100	100
Nortron 3	458	112	103	210
Fatol 1	464	130	na	na
Fatol 2	534	116	131	223
Fatol 3	459	149*	114	190
Fatol 4	na	173*	na	na
Fatol 4 2X	455	177*	na	na

* - Significantly different from the control at P=0.05

na - data not available

Actual seed yields in the three Nortron treatments at site 2 were not as low as expected given the number of inflorescences produced and the visible injury observed following chemical application. None of the Fatol Super treatments showed a significant effect on seed yield (Figure 3).

The two chemicals used in this study had no detrimental effect on seed viability despite the fact that Nortron, in particular, had an obvious visible effect on plant growth. Seed from all treatments showed high levels of viability (>95%), although minor differences existed in the percentage of hard seeds and normal seedlings. Abnormal seedlings were slightly higher in Nortron treatments, but other components remained similar.

DISCUSSION

The injurious effects of Nortron on plant growth reduced its value as a plant regulator for manipulating shoot status in birdsfoot trefoil. Although this chemical may have other benefits, such as weed control, it appears

to offer little value for use in post-peak flowering shoot manipulation. None of the Nortron treatments improved seed at site 1 as a result of reduced inflorescence numbers following chemical application. The fact that Nortron treatments 2 and 3 at site 2 did not outyield the untreated control is explained by the fewer inflorescences produced in these two treatments. However, a higher seed yield in the Nortron 1 treatment is unclear. Possible hypotheses might include Nortron's herbicidal effect in removing weeds (particularly white clover); Nortron's observed effect in reducing lodging; and a possible reduction in pod dehiscence. These two latter aspects might be expected to improve seed recovery and seed yield at harvest. The number of inflorescences produced at peak flowering in this treatment was similar to that in untreated plants, although the total number of inflorescences in this treatment was much lower than in untreated plants.

The effect of Fatol Super was clearer. This chemical appears to show considerable promise in the manipulation of the post-peak flowering shoot population. However, the fact that its short-term effect, which was visibly reduced within ten days following application, suggests that a single application is inadequate to achieve long-term effects in controlling the continual emergence of new shoots. Early application (pre-peak flowering) of this chemical is obviously not appropriate since it may simply reduce shoot numbers available for flowering. Post-peak flowering application, however, is likely to be beneficial in reducing competition for assimilate by late emerged shoots. The increased seed yield obtained following the two late applications at site 1, in particular, suggests Fatol Super might be of value as a plant growth regulator for reducing post flowering vegetative shoot competition in *Lotus corniculatus*.

Problems with spray application of Fatol Super to ensure penetration of the vegetative canopy in order to reach the site of activity at the crown were encountered

at site 2. Because of its contact-action, Fatol Super solution must drain down the stem to reach the young vegetative crown shoots. At peak flowering, sward crops of *Lotus corniculatus* have a large vegetative canopy which effectively prevents or restricts spray penetration to the crown. This tightly closed canopy at site 2 perhaps accounted for the failure of this chemical to control late shoots. It was also observed at site 2 that under tightly closed canopy conditions, very few new shoots were formed naturally in the heavily shaded crown area during the post-peak flowering period.

The success of Fatol Super for post-peak flowering shoot control is only likely to be advantageous in crops grown in wide rows where adequate spray penetration to the crown is more readily possible. Its short-term action also makes repeat application necessary. Nevertheless, the improved seed yield by late applications at site 1 demonstrates the potential of this chemical as a means of achieving better seed production in *Lotus corniculatus*.

ACKNOWLEDGEMENT

The senior author gratefully thanks the Miss E.L. Hellaby Grassland Memorial Trust for providing financial support during this research programme.

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