DURATION OF WEED INTERFERENCE AND YIELD OF PROCESSABLE GREEN BEANS

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SUMMARY

Continuous weed interference throughout the growing season reduced processable pod yield of green bean (*Phaseolus vulgaris* cv. Gallatin 50) from 2.64 kg/m² to 1.44 kg/m². Removal of weeds for the first 42 days after sowing was necessary to prevent a significant reduction in yield. The presence of yield reducing weed populations primarily affected pod number and weight rather than the proportion of processable pods.

INTRODUCTION

The timing and duration of the period during which weed interference must be absent to avoid crop yield loss is of great practical significance. If weed control measures precede the period, then an increase in crop yield may be anticipated, but if applied after, then the prime advantage of weed control is lost, although there may remain other benefits such as ease of harvest.

The range of cultivar types from the species *Phaseolus vulgaris* have typically been sown in wide rows (>30 cm) and present practice in New Zealand is to sow in 38 cm rows. This presents considerable opportunity for weed invasion and the establishment of early competition, which may reduce final yield. Dawson (1964) and Williams *et al* (1973) showed that early establishing weeds had a major effect on green bean yield. The use of pre-sowing herbicide treatments such as trifluralin and EPTC may give satisfactory control of early weeds, although field performance is frequently erratic and there is incomplete control of some annual and most perennial weeds. Failure of pre-sowing herbicide treatments cannot be easily remedied because of the limited range of selective post-emergence herbicides available. As a result high weed populations often develop.

This study is an extension of work already reported on the use of high plant populations, which may restrict weed interference (Field and Nkumbula 1985). It reports on the effect of duration of weed interference which may be related to the persistence of pre-sowing herbicide treatments on total green bean yield and the quality of production as measured by pod size and the timing and uniformity of crop maturity.

MATERIALS AND METHODS

A field trial was established on a Wakanui silt loam soil at Lincoln College, in 1980-81. The trial was a randomised block design with five replicate blocks each containing five weeding treatments. Each plot was 16 m long and 2.3 m wide and was drilled with the green bean cv. Gallatin 50, on 17 December 1980. The crop was drilled in 38 cm wide rows, with 7 cm spacing within the rows, to establish a plant population of 38 plants/m².

The duration of weeding treatments involved regular hand weeding for specified periods after crop sowing. Plots were carefully weeded with a hand hoe for 0, 21, 42, 63 or 76 days, at 7 day intervals. The final harvest of the green beans and weeds commenced after 76 days. To allow for the spread of crop maturity associated with the weeding treatments, three harvests were taken at 2 day intervals (Field and Nkumbula 1985). Each plot had three sample areas of 2 m of row length. The timing of the first harvest was based on determination of crop maturity, assessed by measuring the mean length of 100 bean seeds taken from the central position of randomly selected, large

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Pods. Harvesting commenced when the mean bean seed length was 10.5 — 11.0 mm, in at least one of the treatments. A randomly selected sub-sample of 10 plants was used for determination of components of green bean yield. To determine crop quality pods were arbitrarily divided into three classes: (i) pods >100 mm in length, (ii) pods >50 mm < 100 mm in length and (iii) tiny, unfilled pods, < 50 mm in length. The processable yield was made up from class (i) and (ii) pods.

At the time of the first green bean harvest randomly selected 1 m² quadrats were taken of the weed populations. The total weight of weeds and a species composition, by weight, were determined.

All data were analysed using analysis of variance and duration of weeding was related to bean growth variables by regression analysis.

RESULTS AND DISCUSSION

Fathen (*Chenopodium album*) was the dominant weed species, particularly in the treatments that were not weeded or weeded after 21 or 42 days (Table 1). In contrast, the other major annual weed, black nightshade (*Solanum nigrum*) was a minor competitor. The three perennial weeds Californian thistle (*Cirsium arvense*), dock (*Rumex obtusifolius*) and couch (*Elytrigia repens*) were collectively significant as contributors to total weed biomass but were unevenly distributed within the plots. One important observation was the reduction in total weed biomass at harvest of 46.6% and 91.3%, following a 21 or 42 day period of weeding, respectively. Such reductions could only be partially associated with crop interference as crop leaf area indices had reached only 0.5 and 1.2 after 21 and 42 days growth, respectively. Exhaustion of germinable seed close to the soil surface plus increasing crop interference was no doubt responsible for the rapid decline in weed establishment and growth during the second half of the trial (Table 1).

TABLE 1: Effect of duration of weeding on weed biomass and allocation of the major weeds species present, at the time of green bean harvest.

	Duration of weeding (days)				
	0	21	42	63	76
Total fresh weight of weeds (g/m ²)	1660	886	144	39	33
Weed species composition (percentage by weight)					
Fathen	77.8	90.0	76.4	59.0	63.3
Californian thistle	11.1	0.6	0.6	15.4	5.4
Dock	6.1	2.0	6.6	4.9	8.4
Couch	2.1	1.8	2.6	1.3	1.8
Black nightshade	1.5	2.8	2.8	7.2	2.1
Other species (normally each species <1% by weight)	1.4	2.8	11.0	12.2	19.9

Weed biomass was not a perfect indicator of weed interference. Fathen plants that germinated in the first 42 days had flowered and were taller (mean height 100 cm) than the crop (mean height 38 cm) at final harvest whereas later germinating plants were shorter and did not compete so effectively for light. No attempt was made to identify the basis of interference by fathen, or other weed species, but previous work has shown the importance of both root and shoot interference by fathen in restricting crop growth (Williams 1964; Martin 1984). In the present study weed interference had little effect on crop establishment and at harvest no treatment significantly deviated from the overall mean population of 39.2 plants/m².

Continuous weed interference throughout the growing season significantly reduced total pod yield, while weed removal for 21 days was insufficient to prevent some reduction in total pod yield (Table 2). A period of 21-42 days weeding, or more was required for maximum total pod yield, a result similar to that obtained by Williams *et*

al. (1973). There was a highly significant quadratic relationship between duration of weeding and yield of either total green beans or processable pods (Table 2). The weight of processable pods (>50 mm in length) produced varied with weeding treatment but paralleled total pod production. There was no significant effect of weeding treatments on the number of pods in the smaller of the processable pod classes, so data for the two larger pod classes have been combined (Table 2). No effects of treatments on the spread of crop maturity or on the distribution of pod size were found, and the mean of the yields of the three individual harvests are presented. In treatments of 42 days weeding or more, greater than 92% of pods, by weight, were in the processable classes (Table 2). Only with continuous weed interference throughout the season was there a significant reduction in the percentage of processable pods. The major effects of weed interference were on total pod production rather than on pod class distribution.

TABLE 2: The effect of duration of weeding on green bean yield and allocation to pod classes. Figures in parentheses refer to the percentage of pods in processable classes. Details of regression analyses are presented.

Duration of weeding (days)	Pod Yield (kg/m ²)		
	Total	Processable (%)	
0	1.66	1.44	(86.7)
21	2.40	2.17	(90.4)
42	2.96	2.74	(92.6)
63	2.97	2.78	(93.6)
76	2.83	2.64	(93.3)
S.E.	0.15	0.15	(1.3)

Regression of duration of weeding x yield (q = quadratic)

significant		
function	q ¹	q ²
r ² (%)	99	99

equations:

$$^1 y = 1.64 + 0.0480x - 0.000424 x^2$$

$$^2 y = 1.42 + 0.0476x - 0.000413 x^2$$

A components of yield analysis indicated that the number of processable pods per plant and individual pod weight were both influenced by duration of weeding and the relationships were quadratic (Table 3). The number of processable pods per plant and hence per m², because of constant plant population, was significantly reduced when weeds were not controlled or were removed for only 21 days. Although the percentage of pods in the processable class increased with each additional period of weeding a more critical yield determinant was the total number of pods produced. Only in the complete absence of weeding was the weight of individual processable pods reduced (Table 3). Thus processable pod yield per plant was influenced by both pod number and individual pod weight in the continued presence of weeds, but only by pod number when weeds were removed during the first 21 days. This study did not determine whether root or shoot competition or a combination of both were responsible for the changes in yield and its components.

One of the dangers of experiments involving weed removal is mechanical damage to crop plants, resulting in yield losses. The bean yield components in the continuously weeded treatment did not significantly differ from the other treatments, although mean values were frequently lower (Tables 2 and 3), possibly indicating some crop damage. There is no easy check of the extent of damage from weeding and crop loss. The yield of a green bean crop grown in the same season (Field and Nkumbula 1985), in which trifluralin was used effectively for control of fathen, was comparable to the highest yields obtained by hand weeding in the present study. Such comparisons and the consistency of plant populations between crop establishment and green bean harvest suggest that weed removal was effective and crop damage and yield loss minimal.

TABLE 3: The effect of duration of weeding on the components of processable green bean yield. Figures in parentheses refer to the percentage of total pods per plant in the processable classes. Details of regression analyses are presented.

Duration of weeding (days)	Pods/m ²	Pods/plant	Weight/pod (g)	Pod weight (g/plant)
0	210	5.4 (42.9)	6.8	36.8
21	262	6.7 (49.3)	8.3	55.6
42	331	8.5 (53.8)	8.2	70.2
63	360	9.2 (58.2)	7.7	71.0
76	323	8.3 (57.2)	8.2	67.6
S.E.	13.8	0.6	0.3	3.8

Regression of duration of weeding x yield component (q = quadratic)

significant function	q ¹	q ²	q ³	q ⁴
r ² (%)	88	88	65	98

equations:

$$^1 y = 202 + 4.48x - 0.0358x^2$$

$$^2 y = 5.19 + 0.114x - 0.000902x^2$$

$$^3 y = 7.00 + 0.0534x - 0.000549x^2$$

$$^4 y = 36.2 + 1.22x - 0.0106x^2$$

CONCLUSIONS

Green bean yield was significantly reduced by continuous weed interference throughout the season (Table 2). Rapidly establishing fathen plants undoubtedly shaded the crop and while not influencing plant establishment, probably contributed to the reduced number and size of pods produced (Table 3). The percentage of pods in the processable classes, greater than 50 mm in length, was reduced by continuous weed interference throughout the season, with the yield of processable pods being 1.44 kg/m² compared to 2.64 kg/m² for weed free treatments (Table 2). When weed invasion was prevented for the first 21 days after crop sowing the subsequent establishment of weeds still had a significant effect on the yield of processable pods, reducing it to 2.17 kg/m².

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