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Effective Weed-Free Period of Common Beans in Two Different Agro-Ecological Zones of Sri Lanka

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ABSTRACT. *The critical period of weed interference for common bean (Phaseolus vulgaris L.) cultivars, bush bean (var. Top Crop) and pole bean (var. Kentucky Wonder Green), was studied at two locations in two agro-ecological zones of Sri Lanka.*

The treatments used were weed-free and weed interference periods for different days after bean emergence (DAE), (7, 21, 35 and 49 DAE) or weed-free and weed infested until harvest in both pole bean and bush beans. Fresh yields were recorded for analysis and nonlinear regression models were fitted to yield data, adjusted as a percentage yield of weed-free beans.

Different critical periods were identified, depending on the differences between cultivars and location. The need of shorter weed-free periods for pole beans was identified regardless of location. Pole bean could be identified as the most suitable bean cultivar for upcountry vegetable growing areas due to its excellent growth and yield with short weed-free period.

INTRODUCTION

The influence of the length of time that weeds are present in a crop on the magnitude of yield losses has generally been analysed in the context of critical period of weed competition or effective weed free period (Weaver *et al.*, 1992). This period represents the time interval between two separately measured components. These components are experimentally determined by measuring crop yield loss as a function of successive times of weed removal or weed emergence respectively (Weaver *et al.*, 1992). The degree of competition exhibited by a weed or different groups of weeds is not an

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inherent factor. It is conditioned by the situation in which competing plants exist (Zimdhal, 1988). Therefore, a critical period of weed interference for a crop is a measure of crop/weed and environmental interaction. Crop density, soil fertility and cultivar can be adjusted to a some extent to obtain advantages on the crop over weeds in the mission of competition. Bandula Premalal *et al.* (1997, 1998) observed a considerable variability associated with critical period of weed interference in common beans in two different seasons of mid-country intermediate zone of Sri Lanka. The main differences between two seasons were the amount of rainfall and temperature.

In Sri Lanka common beans are grown in different agro-ecological zones, characterized mainly by differences in annual rainfall patterns. However, the relationship between crop yield loss and weed interference should be evaluated at different locations before developing recommendations. Therefore, the objectives of this experiment were to determine critical periods of weed interference for common beans in two different agro-ecological zones of Sri Lanka (mid-country intermediate and mid-country wet zones) and to demonstrate the influence of different locations on critical weed-free periods in common beans.

MATERIALS AND METHODS

Field experiments were conducted at University Experimental Stations at Dodangolla (DG) and Meewatura (MW), which are located in mid-country intermediate and wet zones of Sri Lanka, respectively. Rainfall and temperature were measured daily and presented on a weekly basis. The bean cultivars used were 'Top Crop', a bush type (bush beans) and 'Kentucky Wonder Green' a vining type (pole bean). Naturally occurring weed populations were used for the competition experiments.

Two sets of treatments, initial weed-free and initial weedy, were used. For the first set, plots were kept weed-free until 7, 21, 35, and 49 DAE. Thereafter weeds were allowed to grow. Bean plots where weeds were allowed to grow until 7, 21, 35 and 49 DAE were the second set of treatments. Thereafter, plots were kept until harvest. In addition, season long weed interference and weed-free treatments were included. All 10 treatments were randomized within blocks and replicated four times.

Bush and pole beans were seeded on 01 May 1997 and 12 May 1997, respectively at MW site, and at the DG site, on 05 May 1997 and 16 May 1997, respectively. At harvest, bean pod fresh weight and number of pods were measured and counted. Critical periods were calculated using, nonlinear regression models. Logistic and Gompertz models were fitted for initial weed-free and initial weed infested situations, using yield data as a percentage of weed-free beans.

RESULTS AND DISCUSSION

Climatic condition of the experimental sites

The two sites have different climatic conditions mainly the amount of rainfall (Figure 1). Therefore, the total rainfall received during the study period (May to August) were 594 and 423 mm for MW and DG sites, respectively. For each week, higher amounts of rainfall were recorded at the MW site. The average temperature experienced at MW was lower than at the DG site (Figure 1).

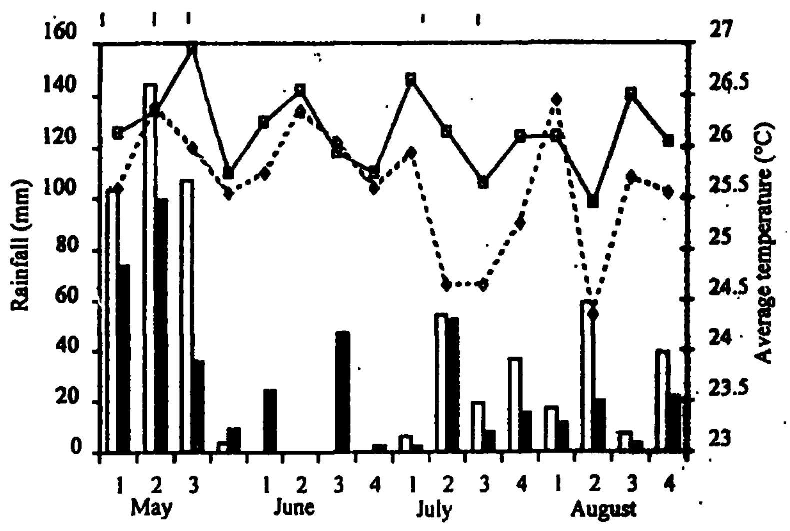

Figure 1. Weekly rainfall and temperature at MW (empty bars for rainfall and dashed line for temperature) and DG (filled bars for rainfall and continuous line for temperature) sites.

The climatic data clearly shows that mid country wet zone received a greater quantity of rainfall. At bean flowering (approximately 35 and 50 DAE for bush and pole beans) the MW site experienced lower temperatures (between 24 to 26°C) when compared to DG site (>25.6°C).

Total rainfall received during July and August were 236 and 130 mm for MW and DG sites, respectively. The rainfall in July and August at DG site was 32% and 55% lower than that of MW. Bean flowering and pod setting occurred during these two months. During the dry periods, plants showed water deficit earlier at DG site than the MW. This is mainly attributed to the higher temperatures which are characteristics of low country intermediate zone during the *Yala* season, as seen in Figure 1.

Critical period of weed interference in bush beans

Parameter estimates for fitted curves are presented in Table 1. All parameter estimates in logistic models were significant (p=0.05 level) in both sites.

Table 1. Parameter estimates for logistic[a] and Gompertz[b] models derived for bush beans at MW and DG sites.

Location	Parameter estimates						
	Logistic model				Gompertz model		
	D	K	F	x	A	B	K
DG	2.7 (0.21)	0.218 (0.01)	1.144 (0.01)	22	100 (12.3)	1.998 (0.43)	0.053 (0.75)
MW	0.924 (0.33)	0.112 (0.02)	1.01 (0.07)	30	100 (13.6)	1.78 (0.56)	0.065 (0.84)

[a] $Y = (((1/D\, e^{(K(t-x))} + F)) + ((F-1)/F)))100$, [b] $Y = A\, _e(-B\, e^{-Kt})$; Y = 1 yield (% of season-long weed-free control); e = exponential function; t = time after bean emergence (days); F, D, and K of logistic and B and K of Gompertz modes are constants. The standard error values are given within parentheses.

As not much differences were observed in parameter estimates between sites for the Gompertz model, weed-free data were combined as one data set and reanalysed. The common Gompertz model fitted is given below.

$$Y = 100.e^{(-1.998.e^{(-0.053t)})}$$

where Y and t represent yield as a percentage of weed-free beans and days after bean emergence.

The Logistic model which represented the weed-infested duration shifted downward when calculated for DG compared to the same curve derived for MW (Figure 2). Estimated values for MW were lower than at DG. The lower values of all parameter estimates of logistic model for MW were symptomatic of greater yield losses due to full season weed interference predicted and that measured in the field. However, the predicted percentage yield by the Gompertz model derived for weed-free data did not reveal high yield losses at MW due to season-long weed interference although observed yield values were lower at MW (Figure 2). This is due to the higher increase in yields in relation to increasing weed free duration from emergence at MW when compared to the DG site. The contrasting behaviours of weed-infested and weed-free curves between sites could also be due to the changes in weed and crop growth associated with differences between sites.

The critical time of weed removal in bush beans as calculated from fitted logistic models decreased from 37 to 0 DAE as the predetermined yield loss level decreased from 10 to 2.5% (Table 2). There was only a minor difference in critical time of weed removal between two sites at 10% or a lower yield loss. Critical periods of weed interference were 11 to 50 DAE and 19 to 37 DAE for 10 and 20% yield loss levels, respectively at DG. The critical period for MW-grown bean were 9 to 50 DAE and 13 to 37 DAE, respectively for the same yield loss levels. At 20% yield loss level, critical period observed at MW site was shorter (Table 2). Therefore, bush beans grown at DG had longer critical weed-free periods. The long critical period at DG indicates a limited competitiveness of bush beans under low moisture regimes. It could also be due to the greater competitiveness of weeds under low moisture levels.

Critical period of weed interference in pole beans

All parameter estimates of the logistic model at MW site were significantly lower than those for DG except the B parameter estimate of

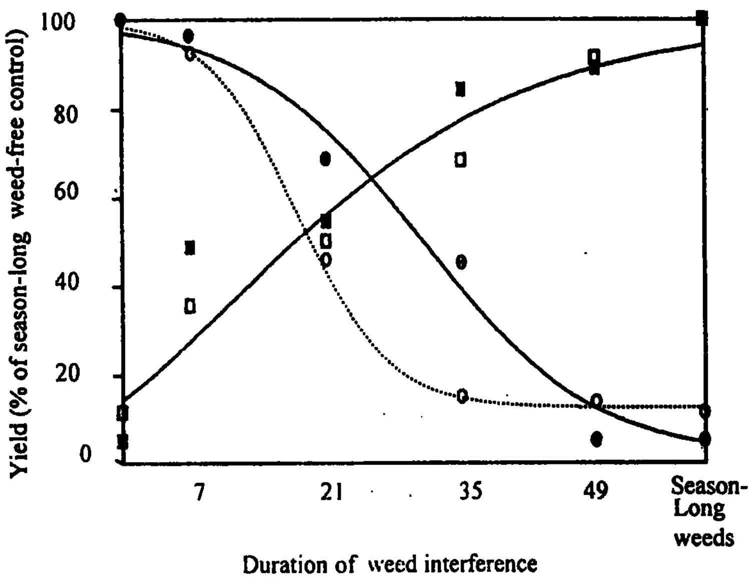

Figure 2. **Bush bean yield (% of weed-free control) as affected by duration of weed-interference with curve for common Gompertz model.**

[Note: incline curve - hard line and filled and empty squares and weed-free periods ; declining curve: —, ● for MW and —, O for DG site].

Table 2. **Critical period of weed removal for bush beans calculated from Gompertz and logistic models for four predetermined levels of crop yield loss.**

Site	Critical periods for indicated % yield loss level (DAE)			
	2.50%	5%	10%	20%
Dodangolla	0-end	4-end	11-50	19-37
Meewatura	2-end	5-end	9-50	13-37

(DAE - days after bean emergence)

Gompertz model for MW, which was higher (Table 3). These observations were symptomatic of greater yield losses due to full season weed interference recorded for MW. At DG and MW, season-long weed interference produced a yield of 40% and 10% of the weed-free treatment, respectively (Figure 3). Therefore, both weed-free and weed-infested curves were affected by the location (Figure 3). Weed-infested (logistic) curve fitted to data at DG shifted downward initially and the data of MW, crossed the logistic curve at 35 DAE. After 35 days of weed-interference, DG logistic curve was above the MW curve. The logistic curves before 35 DAE shows a lower number of days that pole beans could tolerate weeds from emergence at DG, resulting in a longer critical period. When weed interference was more than 35 DAE, effect of weeds on bean yield was higher at MW than DG. This could be due to the heavy weed growth observed at MW (data not presented). Weed-free curves also showed a similar pattern. From 0-21 DAE, DG weed-free curve appeared above the MW curve and thereafter shifted downward (Figure 3). The behaviour of the weed-infested curve until 35 DAE and weed-free curve after 21 DAE could be explained by the findings of Weaver *et al.* (1992). They observed that the length of time seeded tomato could tolerate weed competition early in the growing season decreases with reducing soil moisture.

Table 3. Parameter estimates for logistic[a] and Gompertz[b] models derived for pole beans at MW and DG sites.

Location	Parameter estimates						
	Logistic model				Gompertz model		
	D	K	F	x	A	B	K
DG	1.360 (0.70)	0.28 (0.06)	1.71 (0.07)	13	100 (13.78)	1.045 (0.180)	0.042 (0.480)
MW	0.429 (0.09)	0.16 (0.02)	1.25 (0.04)	24	100 (11.09)	3.500 (2.200)	0110(1.700)

[a]$Y=(((1/D\, e^{(K(t-x))}+F)) + ((F-1)/F)))100$, [b]$Y = A_e(-B\, e^{-Kt})$; Y = yield (% of season-long weed-free control); e = exponential function; t = time after bean emergence (days); F, D and K of logistic and B and K of Gompertz modes are constants, Values within parenthesis show standard error.

Moreover, they found greater effects of weed density on weed-free curve in direct seeded tomato. Weed-free curves also shifted downward with increasing weed density as seen in the present study. When these factors (*i.e.* low soil moisture and high weed growth) are combined weed-free and weed-infested curves could be affected and eventually cause an increase in period that a crop must be kept weed-free late in the season. It also shortens the period that the crop can tolerate competition early in the season in order to prevent yield losses (Weaver *et al.*, 1992).

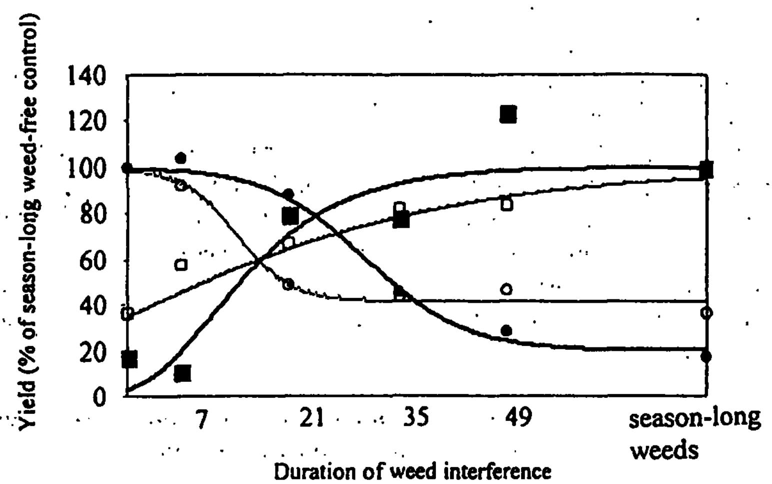

Figure 3. Pole bean yield as % of weed-free control as affected by duration of weed-interference.
[Note: declining curves: ___, ● for MW and ___, O for DG site and weed-free periods, incline curves: ___, ■ for MD and ___, □ for DG site]

Differences in rainfall and weed growth (data not presented) at the two locations resulted in different critical period of weed interference for pole beans (Table 4). Critical periods for pre-defined yield loss levels at MW were also shorter than those at DG. This is clearly in agreement with Weaver's (1992) explanations as cited previously. Since weed populations observed under crops are related to soil moisture availability, variations in the critical periods observed in the present study could be due to the difference in rainfall received. In contrast, Coble *et al.* (1981) reported that the critical period of weed-interference for soybean was 2 weeks in a dry year and 4 weeks in a wet year when competing with natural populations of common ragweed (*Ambrosia*

Table 4. Critical period of weed removal for bush beans calculated from Gompertz and logistic models for four predetermined levels of crop yield loss.

Site	Critical periods for indicated % yield loss (DAE)			
	2.50%	5%	10%	20%
Dodangolla (DG)	2-end	5-end	8-54	11-36
Meewatura (MW)	9-45	14-38	19-32	-

(DAE - days after bean emergence)

artemisifolia). However, weed and pole bean relationship under season-long weed-interference is not in agreement with that of Weaver (1992). Although adequate rainfall and low weed densities were observed at MW, yields under season-long weed-interference treatment were also lower. This could be due to the differences in weed species spectrum observed between two sites. At MW, *Panicum maximum* was the most common weed species found under pole beans and infection was very severe since the weed grew as high as beans. Due to this fact, pole beans were unable to suppress weed growth when *P. maximum* was observed from the time of bean planting, even though environmental conditions were favourable. In contrast DG was dominated by broad-leaved weed species.

CONCLUSIONS

The field study conducted at two locations illustrated the followings.

A single critical period for bush bean can be developed, namely 9 to 50 DAE for a 10% yield loss. This critical period could be due to its determinate growth habit. After reaching a maximum growth (flowering) bush beans do not compete with weeds and produce pods with available food resources.

Pole bean needs a shorter weed-free periods than bush beans regardless of location or weed growth. In general, pole bean can be grown with one weeding to obtain yields similar to that of a full season weed-free period. This is due to the indeterminate growth habit which results in a longer economic life-span and the support given. Supporting bean plants to grow along poles, automatically reduces the aboveground competition with weeds.

Yield differences between sites is primarily due to poor growth of beans associated with low moisture availability and not due to heavy weed growth. Low moisture availability or any other type of environmental stress could affect crop growth resulting in low yields even in the absence of weeds.

Pole beans could be identified as a suitable bean cultivar for mid-country wet zone areas where most of the farmers grow vegetables in hilly slopes. With minimum of one weeding, they can obtain higher yields while protecting their valuable soil from erosion, occur by rains after clean weeding.

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