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Full Length Research Paper

Competitive effects of redroot pigweed *(Amaranthus retroflexus)* and lambsquarter *(Chenopodium album)* on potato

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In order to study the effects of redroot pigweed and lambsquarter densities on potato yield, an additive experiment were conducted in 2004 and 2005. This experiment was done in split plot based on randomized complete block design with four replications. Treatments were two weed species in main plots and weed density in sub plots (0, 2, 4 and 8 plant per meter of row). Hyperbolic and exponential models were used to model the effect of redroot pigweed and lambsquarter densities on potato yield. The best model was the hyperbolic model. However, the differences between two models were not significant. 2, 4 and 8 plant of redroot pigweed per meter of row reduced potato yield 15.72, 28.55 and 36.04% in 2004 and 13.18, 23.05 and 31.85% in 2005. These values for lambsquarter were 9.73, 18.84 and 25.09% for 2004 and 8.28, 15.17 and 21.59% for 2005.

Key words: Competition, *Amaranthus retroflexus*, *Chenopodium album, Solanum tuberosum*.

INTRODUCTION

A successful integrated weed management program for the control of weeds cannot be implementing without a clear understanding of inter-specific competition between major field crops and weeds (Eslami et al., 2006). Weed density and relative time of weed emergence have impacts on crop weed interactions. The timing of weed emergence relative to crop emergence is important to crop growth and yield. Weeds emerging before the crop cause greater yield loss (Bosnic and Swanton, 1997; Dieleman et al., 1995; Knezevic et al., 1994, 1995; Murphy et al., 1996; O'Donovan et al., 1985; Steckel and Sprague, 2004; Chikoye et al., 1995; Kropff, 1988), produce more seed (Bosnic and Swanton, 1997; Peters and Wilson, 1983), and have higher shoot weights and competitive indices (Martin and Field, 1988).

Potato (*Solanum tuberosum* L. *var*. Agria) is one of the most important field crops in Iran and due to its role in providing food and proteins for an increasing population; area under cultivation and yield of potato is increasing rapidly (Anonymous, 2005). Redroot pigweed (*Amaranthus retroflexux*) and lambsquarter (*Chenopodium album*) are highly competitive weeds that are widely distributed through cropping area of Iran and cause large potato yield losses. Nelson and Thoreson (1981) indicated that potato yield were 31 and 39% less in the low (58 plant/m^2) and high weed (311 plant/m^2) density plots. In other study, competition between foxtail and potato for 2 weeks after potato planting caused 19 and 29% reduction in total and marketable tuber yield. However, after 10 weeks interference, these values increased to 69 and 86%, respectively (Wall and Friesen, 1990).

Love et al. (1995) showed that emerging weed before potato reduce yield 68%, but when weeds emerge after potato, this reduction will be 25%. The hyperbolic yield-density model for the description of yield loss in relation to weed density is the most widely used regression model to describe effects of competition at a certain moment (Cousens, 1985b; Spitters et al., 1989). This simple empirical model usually gives satisfactory post hoc descriptions of crop loss but tend to fail when it is used

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Table 1. Results of soil analysis.

Texture	Clay (%)	Silt (%)	Sand (%)	P (ppm)	K (ppm)	Total N (%)	SP (%)	pH	B (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)	Fe (ppm)	Ec (dc/m)	O.C (%)	T.N.V (%)
Loamy	16	40	44	14.4	178.4	0.08	24.63	7.36	0.464	17.72	1.34	0.5	7.72	1.33	0.79	10.1

predicatively because its parameters are highly variable between experiments (Kropff et al., 1984; Firbank et al., 1990). The objective of this research was to study the effects of density and relative time of emergence of redroot pigweed and lambsquarter on potato yield.

MATERIALS AND METHODS

Experimental site

Field experiments were conducted at the research station of Seed Potato Production of RAN in Firouzkooh (33° 55′ N, 52° 50′ E and 1975 m mean sea level) in 2004 and 2005 growing seasons. The soil of the experiment plots was loamy in texture with pH = 7.36 (Table 1).

Sources of materials

Experimental materials used include Delta-T Area Meter, WinDIAS, obtained from Delta-T Devices Ltd., 128 Low Road, Burwell, Cambridge, CB5 OEJ, U.K and SAS software (version 9.0 for windows).2002 obtained from SAS Institute Inc. Cary, NC, 27513, USA.

Experimental procedures

Fertilizers (100 kg ha^{-1} N and 50 kg ha^{-1} P_2O_5) were applied with crop planting at the same time. For each year and location, primary tillage consisted of spring disking followed by field cultivation before planting. Potato was planted in constant density (5.33 plants per m^2) in May 26, 2004 and May 27, 2005.

Experimental design and measurements

This experiment was done in split plot based on randomized complete block design with four replications. Individual plots size was 3 m wide by 8 m long. Treatments were two weed species in main plots (redroot pigweed and lambsquarter) and weed density in sub plots (0, 2, 4 and 8 plant per meter of row). Plots were consisted of four 8-m rows with 75 cm spacing between rows. Potato seed tubers were planted with 25 cm apart in the rows. Weeds were hand planted in 0.5 cm depth. In the 3 to 4 leaf stage, weed seedlings thinned and field was hand hoed to remove undesired weeds that had emerged.

Data of the plant height (cm) and leaf area (LA) were recorded. Both potato and weeds were sampled at 2 weeks intervals for height and LA. Measurements and samplings were done on the inner two rows in each plot, discarding 50 cm from both ends to avoid edge effects. Five plants of each species were taken randomly from each plot at each sampling date. Plant height was measured for each plot using a ruler (± 0.1 cm) from the base to the tip of plant. Leaf areas were determined with a Delta-T leaf-area meter. According to the LA data, leaf area index (LAI) calculated. Fresh weights of tubers from the two middle rows were recorded. For each plot in each replication, percentage yield loss was calculated as (YWF - *Y*D)/YWF × 100%, where *Y*D is the yield under that treatment and YWF is weed free yield (weed density = 0).

Statistical analysis

All data were subjected to the statistical analysis (one-way ANOVA) using SAS software (SAS Institute Inc, 2002). Means of comparisons were performed by Duncan's multiple range test (DMRT) at 5% probability level. Data were transformed when necessary before analysis to satisfy the assumptions of normality. However, any values mentioned in this section refer to the original data of present experiment. The relationship between crop yield loss and weeds density was analyzed with the rectangular hyperbolic model. Hyperbolic regression model has been widely used to characterize the influence of weed density (Cousens, 1985b):

$$Y_L = \frac{ID}{1 + \frac{ID}{A}} \quad (1)$$

where Y_L is percent yield loss, D is weed density (expressed as plant/meter of row), I is %yield loss when $D \rightarrow 0$ and, A is the upper asymptote or maximum yield loss ($D \rightarrow \infty$).

RESULTS

Strong effects of weed density on potato growth and yield were observed. The addition of redroot pigweed and lambsquarter to the potato crop reduced the height and LAI of potato. The lowest potato height was recorded at the highest weed densities. At 8 weed plants per meter of row, redroot pigweed and lambsquarter caused 24.7 and 16.5% reduction in potato height in 2004 and 19.9 and 12.9% in 2005.Clearly, redroot pigweed had more competitive effects on potato height than lambsquarter in both years (Figures 1 and 2).

The maximum LAI of potato reached at 75 days after planting (DAP) when no redroot pigweed or lambsquarter was present. Not surprisingly, the lowest LAI for potato was recorded in the plots with highest weed density. At the highest densities of redroot pigweed, LAI of potato was reduced by 60.1 and 39.5% at 2004 and 2005, respectively. These values for lambsquarter were 44.4 and 32.9% (Figure 3). By increasing weed density, leaf area duration (LAD) and LAI started to decrease sooner in comparison with weed free plots (Figure 3).

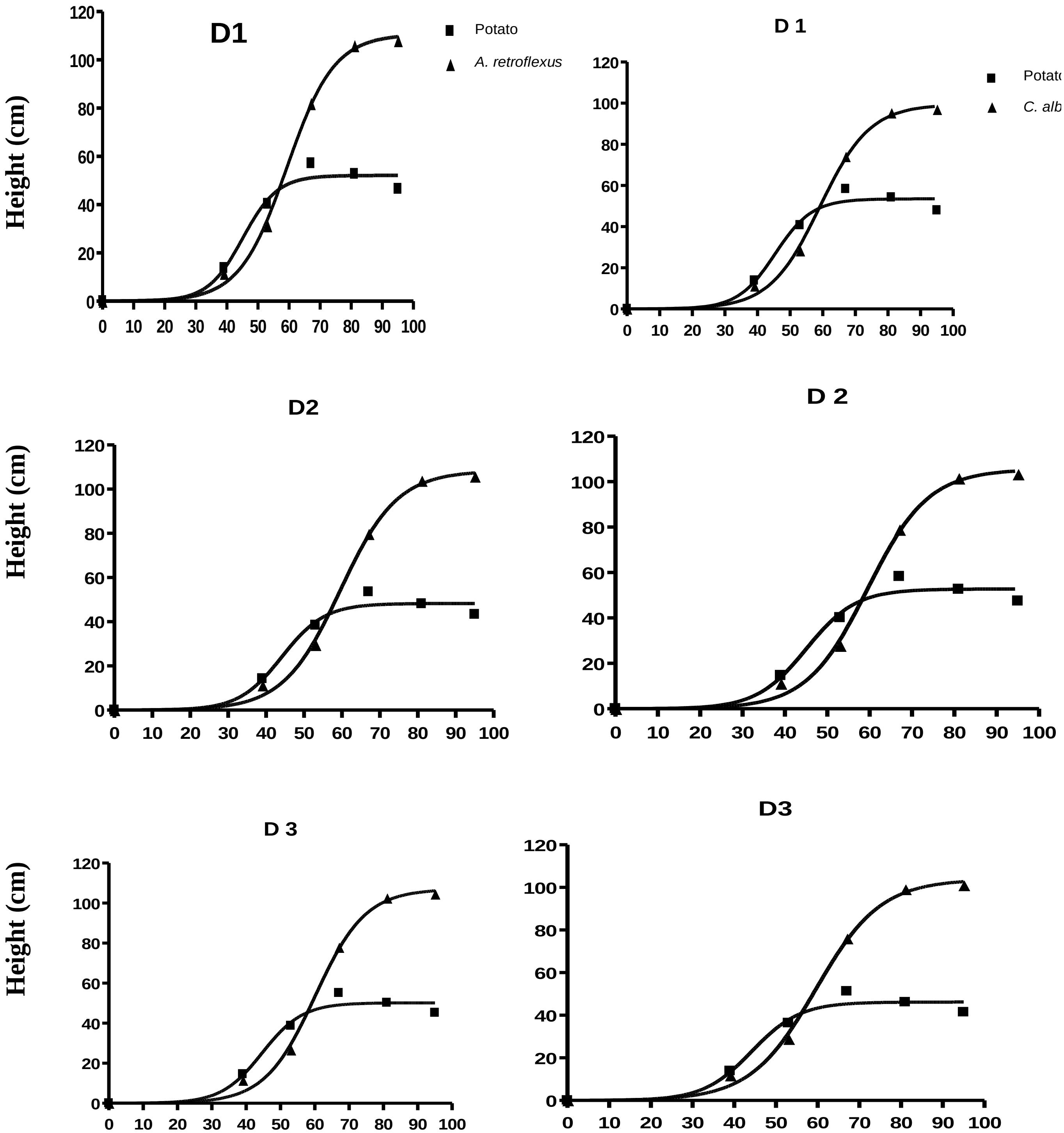

Figure 1. Changes in crop and weed height in response to various densities of lambsquarter and redroot pigweed in 2004. (D1, D2 and D3 are 2, 4 and 8 weeds plant per meter of row, respectively).

Results showed that hyperbolic model was appropriate to represent the relationship between *A. retroflexus and C. album* densities and potato yield losses. Based on *I* estimation, redroot pigweed was the most competitive weed species in 2004 and 2005. Parameter *I* in redroot pigweed in 2004 was more than *I* values estimated for lambsquarter. *I* parameter for redroot pigweed changed 21.5% among 2 years while this variation for lambsquarter

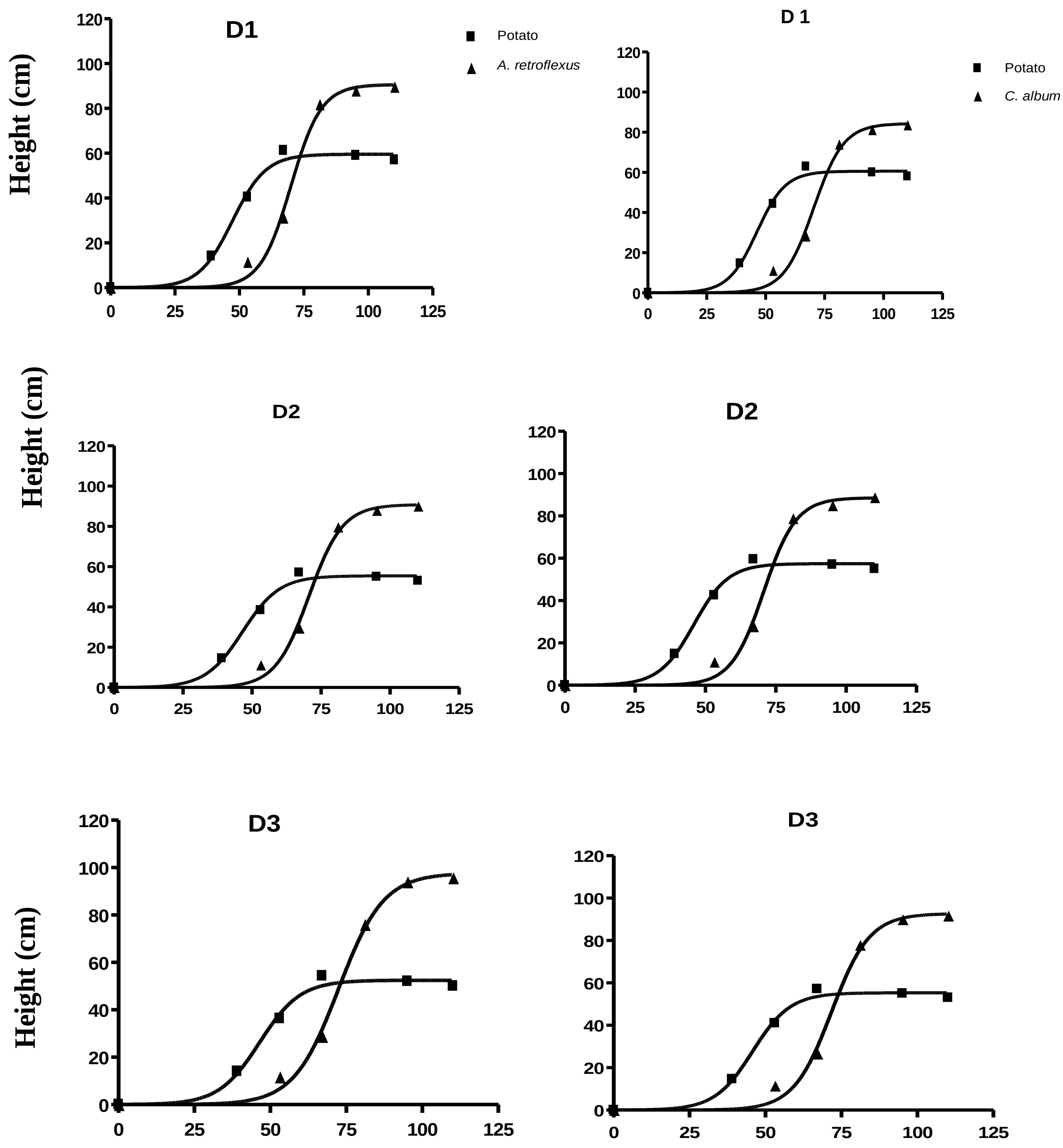

Figure 2. Changes in crop and weed height in response to various densities of lambsquarter and redroot pigweed in 2005. (D1, D2 and D3 are 2, 4 and 8 weeds plant per meter of row, respectively).

lambsquarter was 5.1%. According to Koutsoyiannis (1973), parameter estimates are reliable when the standard error is less than half of the numerical value of the estimate. As the standard errors associated with each estimate are small, estimates *I* and *A* appear to provide a reliable comparison between the treatments (Table 2).

Potato yield was influenced by the changes in weed

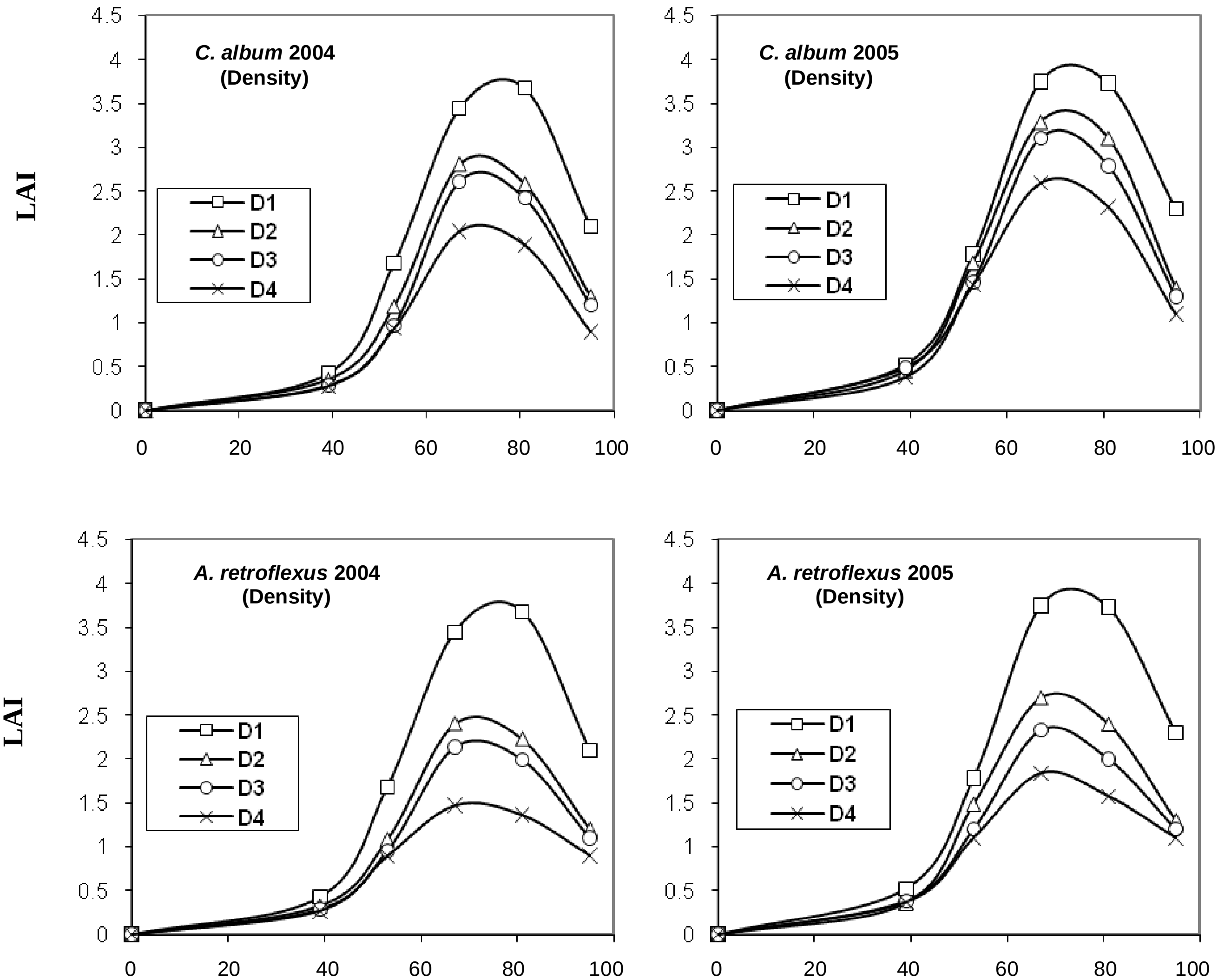

Figure 3. Changes in potato LAI in response to various densities of lambsquarter and redroot pigweed in 2004 and 2005 (D1, D2, D3 and D4 are 0, 2, 4 and 8 weed plants per meter of row, respectively).

Table 2. Parameters estimated for Weed density model.

Species	Parameter	2004	2005
	I	18.32 (4.80)	13.05 (3.18)
Amaranthus retroflexus	A	63.48 (11.45)	65.17 (14.48)
	R^2	0.88	0.89
	I	9.95 (2.07)	9.51 (2.43)
Chenopodium album	A	57.19 (12.2)	46.86 (10.85)
	R^2	0.91	0.87

Standard errors are presented in the parentheses.

density. In both years as redroot pigweed and lambsquarter density increased, the potato yield decreased substantially. Maximum yield loss (A) for redroot pigweed was more than lambsquarter in 2004 and 2005. Estimation of parameter A did not vary among two years for both species (Table 2). Tuber yield was affected by weed species and density. 2, 4 and 8 plant of redroot pigweed per meter of row reduced potato yield

15.72, 28.55 and 36.04% in 2004 and 13.18, 23.05 and 31.85% in 2005. These values for lambsquarter were 9.73, 18.84 and 25.09% for 2004 and 8.28, 17.15 and 23.59% for 2005.

DISCUSSION

Crop height reduction by weed competition has reported in previous studies (Nelson and Thoreson, 1981; Torner et al., 1991 Toller et al., 1996; Aghaalikhani 2001; Swanton et al., 2003). In our study, by increasing weed density, potato height decreased, significantly. Which is in accordance with previous studies? Results on potato LAI showed that redroot pigweed could decrease leaf area index of potato more than lambsquarter. Also, other researchers have shown that weeds could decrease leaf area index in maize, wheat, bean, potato and soybean (Toller et al., 1996; Peterson et al., 1995; Agha-alikhani, 1380; Khaleghi, 2004).

Parameters *I* did not vary among years for lambsquarter. However, for redroot pigweed, this parameter decreased from 2004 to 2005 (Table 2). Other studies also have shown that this parameter is constant among years and locations (Dieleman et al., 1995; Cousens, 1985a), while, variation in *I* and *A* parameters across years, also, have been reported in previous studies (Bensch et al., 2003; Chikoye et al., 1995; Cowan et al., 1998; Knezevic et al., 1994; Massinga et al., 2001), and in our study could have been due to differences in climatic factors across seasons.

Vangessel and Renner (1990) indicated that one redroot pigweed per meter of row reduced marketable tuber yield 22-34%. When density increased to 4 plants per meter of row, potato tuber loss was 40%. In this study hyperbolic model had better results for fitting density data. However, Exponential model can be presented as a suitable model to represent the weed competition with potato.

Conclusion

This study determined that density of redroot pigweed and lambsquarter affect potato yield. Results of this study can be incorporated in integrated weed management program for potato. It could serve as the basis for making economic decision rules for managing redroot pigweed and lambsquarter in potato. A decision rules–based model is needed to assist potato growers in making informed decisions regarding the management of redroot pigweed and lambsquarter.

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