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Marigold (*Calendula officinalis*) yield as affected by lamb's-quarters (*Chenopodium album*) competition

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Abstract

To study interferential effect of lamb's-quarters (*Chenopodium album* L.) on marigold (*Calendula officinalis*) yield and lamb's-quarters seed production two factorial field experiments were conducted in Tabriz, Iran, during 2010-2011. Treatments were densities of lamb's-quarters (0, 2, 4, 6 and 8 plants per meter row) and relative times of its emergence (0, 10, 20, 30 and 40 days after marigold emergence). Marigold could tolerate4 lamb's-quarters plants per meter row without any significant yield reduction, when it emerges 40 days after that of marigold. A suitable fit to model of Cousens et al. was obtained for all marigold flower yield data sets at interference with lamb's-quarters. Results also indicate that controlling lamb's-quarters early in the season may reduce its seed production capacity.

Keywords: Lamb's-quarters seed production; Weed-free; Crop yield loss.

Introduction

Marigoldis a poor competitive plant with weeds and its ability to compete with weed in Iran relies heavily on the application of herbicides (Omidbeigi, 2009). Lamb's-quarters (*Chenopodium album*) is a fast-growing annual weed and it is considered to be a noxious weed and causes serious crop losses (David et al., 2010). Having enough information about weed interference with marigold is necessary to predict the consequences of weed management in this crop. Weeds reduced corn yield by approximately 77%

when allowed to compete with the crop from planting through harvest (Mahmoodi and Rahimi, 2009). When only two Palmer amaranths per meter row emerged along with marigold, flower yield was just reduced, while when they emerged 40 days after crop emergence yield reduction was negligible (Tabrizian et al., 2009). The effect of lamb's-quarters competition and its time of emergence on the yield of marigold are not well understood. Thus, this study was conducted to determine the effect of various densities of lamb's-quarters and its emergence times on marigold yield and lamb's-quarters seed production.

Materials and Methods

Two field experiments were conducted to study interference of lamb's-quarters with marigold during 2010-2011 growing seasons at Tabriz, Iran, on a *Kampar*, local variety of marigold. Rates of precipitation within five months of the experimental growing seasons (April-August) were 93 mm and 99 mm, respectively. Treatments were five lamb's-quarters densities (0, 2, 4, 6 and 8 plants per meter row) and relative times of weed emergence (0, 10, 20, 30 and 40 days after marigold emergence). To break dormancy of lamb's-quarters seeds were presoaked in a 100 ppm GA_3 solution (Kaya and Palziana, 2009). Lamb's-quarters seedlings were thinned randomly and counted at the cotyledon to one-leaf stage to get the desired densities. The essential oil from marigold flowers was extracted by hydro-distillation using Clevenger's apparatus.

The effects of different plant densities and dates of lamb's-quarters emergence on flower yield of marigold were analyzed according to the following equation suggested by Cousens et al. (1987).

$$Y=Y_{WF}[1 - X_2D/100(e^{X_3T} + X_2D/X_1)] \quad (1)$$

where Y stands for the observed yield (g m^{-2}), D for the density of lamb's-quarters plants per meter row, Y_{WF} for the estimated weed-free yield and T for the time of lamb's-quarters emergence relative to the crop. X_1 represents the maximum yield reduction, X_2 represents maximum yield loss per lamb's-quarters plant as D approaches 0 and X_3 is the index of crop competitiveness.

The effects of plant densities and dates of emergence on lamb's-quarters seed production were estimated by the equation 2 used by Bosnic and Swanton (1997).

$$SP = X_1 D / (e^{X_3 T} + (X_1 D / X_2)) \quad (2)$$

where *SP* is the lamb's-quarters seed production (number of seeds m^{-2}) as function of weed density (*D*) and time of weed emergence relative to the crop (*T*), X_1 is the number of seeds per plant as *D* approaches 0, X_2 is the maximum seed produced m^{-2} and X_3 is the rate at which X_1 decreases exponentially as relative time of weed emergence increases.

Results

Parameters estimated to formulize the model proposed by Cousens et al. (1987) and measurements of marigold dry flower yield against interference with lamb's-quarters are presented in Table 1. Lowest flower yield and highest percent yield loss was observed in season-long weedy plots with 6 and 8 lamb's-quarters m^{-1} crop row. In this trial, essential oil of marigold flower was not affected by lamb's-quarters interference, and then essential oil yield data follows the same trend as marigold flower yield. A proper fit of Equation 1 was obtained to all marigold flower yield data sets (Figure 1). The estimated weed-free marigold yield value (Y_{WF}) did not differ from that of observed weed-free yield.

Table 1. Estimated values for the parameters used in the model of Cousens et al. (1987), $Y = Y_{WF}[1 - X_2 D / 100 (e^{X_3 T} + X_2 D / X_1)]$, ($R^2$=0.89) to quantify marigold dry flower yield as affected by the lamb's-quarters density at the various dates of its emergence relative to marigold.

Parameter		Estimated values	Standard error
X_1 [a]	%	50.09	20.00
X_2	%	4.28	1.19
X_3	-	0.95	0.29
Y_{WF}	g m^{-2}	151	19
Observed weed-free yield	g m^{-2}	147	17

[a] X_1, X_2 and X_3 are parameters of the model, and represent the maximum yield reduction, maximum yield loss per lamb's-quarters plant as *D* approaches 0 and index of crop competitiveness, respectively and Y_{WF} indicate estimated weed-free yield.

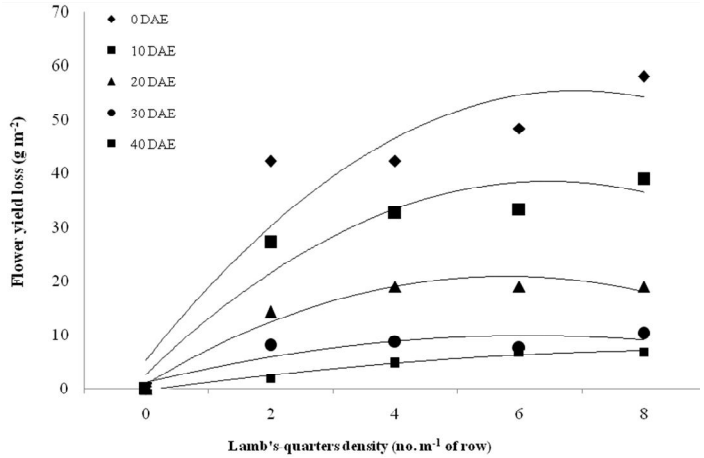

Figure 1. Dry flower yield loss of marigold as affected by the lamb's-quarters density at it's various times of emergence relative to marigold. Points represent mean values and curves are the result of fitting the data observed to Equation 2. DAE means days after crop emergence.

Lamb's-quarters seed production varied with the time of seedlings emergence as related to marigold and lamb's-quarters density (Figure 2). Two lamb's-quarters seedlings, emerging along with marigold, produced at maturity about 129×10^3 seeds m^{-2} as compared to the 56×10^3 seeds m^{-2} from seedlings emerged at 40 DAE. The number of seed produced per lamb's-quarters plant decreased as emergence time delayed at all densities.

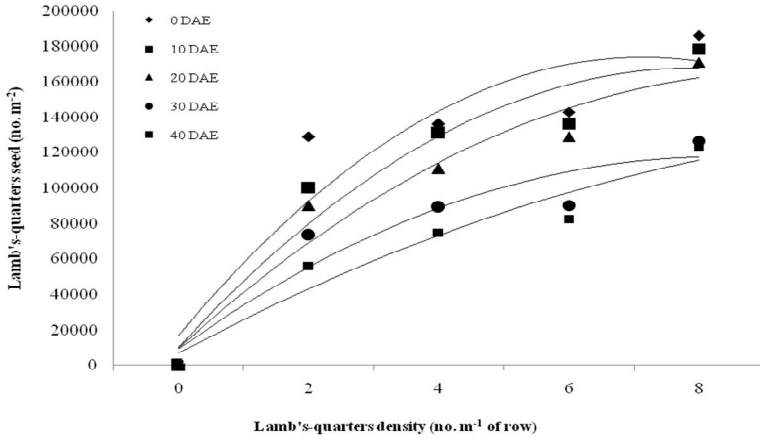

Figure 2. Lamb's-quarters seed production as affected by its density and various times of emergence relative to marigold. Points are the observed data, and curves are the result of fitting the data observed to Equation 3. DAE means days after crop emergence.

Discussion

Weeds emerging at the later stages of marigold growth were less competitive than earlier emerging weeds. Lamb's-quarters seedlings that emerged along with marigold caused greater crop flower yield reduction than later-emerging weeds at similar densities. For example, 6 or 8 lamb's-quarters m^{-1} emerging along with the crop resulted in an average of 53.3% yield loss as compared to 6.8% for emergence at the 40 DAE. On the other hand, our trial suggests that weeds emerging several days after that of marigold may have a minimal adverse impact on yield even when present at high plant densities. Since early emerging weeds are in a better position to have moisture, nutrients and light, it can be said that they affect crop yield more than that of late emerging weeds. Therefore, lamb's-quarters emergence time, against that of marigold is more critical than weed density, to affect marigold flower yield. This is in conformity with results obtained from other studies like the competition of barnyard grass (*Echinochloa crus-galli* L.) with corn (*Zea mays* L.) (Bosnic and Swanton, 1997) and redroot pigweed (*Amaranthusretroflexus* L.) with sugar beet (*Beta vulgaris* L.) (Mirshekari, 2009).

Assuming simultaneous emergence of lamb's-quarters and marigold, the initial slope value was 4.28 (±1.19). Theoretically, as lamb's-quarters density increased, a maximum yield loss of 50.09 (±20) was predicted. This compares to a value of 2.25 for capsell (*Capsella bursa-pastoris*) in marigold (Abd-El-Khalil and Al-Nasr, 2006), suggesting that lamb's-quarters is a stronger competitor than capsell. This yield loss function can be used to estimate economic threshold values for lamb's-quarters in marigold. The index of crop competitiveness, parameter X_3, was 0.95 (±0.29). This would suggest that marigold is more competitive against late emerging weeds. As reported by Bosnic and Swanton (1997), standard errors lower than half of the numerical value of the estimate, as observed in this study, are considered to be highly accurate estimation of crop yield.

Lamb's-quarters produced 27200, 16400, 11700 and 11900 seeds per plant at densities of 2, 4, 6 and 8 plants per meter row, respectively. These estimates of seed productivity within a marigold crop were similar to values reported by Harrison (1990) in a competition study between lamb's-quarters and soybean, but differed from values reported by Colquhoun et al. (2001) in their study on common lambs quarters-soybean. Differences in reproductive output on lambs quarters maybe attributed to several factors included

differential plasticity among biotypes, environmental conditions, particularly nutrient availability, day length, plant density and competitive ability of the associated crop (Bosnic and Swanton, 1997).

Conclusion

The time of lamb's-quarters seedling emergence relative to marigold growth was fundamental in determining the outcome of lamb's-quarters-marigold competition. This indicates that when the weed plants were controlled early enough in the season, its seed production would be minimized, while flower yield of marigold would be maximized.

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