Yield loss by weeds interference can be predicted by empirical models: Case study: Marigold-lambsquarters interspecific competition

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Abstract: Marigold (*Calendula officinalis*) is a poor competitive plant against weeds especially during the earlier growth period and its production in Iran relies heavily on herbicides to control weeds. In order to modeling of lambsquarters (*Chenopodium album*) competition in marigold field an experiment was conducted during 2010-2011 at Tabriz, Iran, with lambsquaters densities; (2, 4 and 6 plants/meter of row) and its emergence times (simultaneously with marigold, 10, 20 and 30 days after crop emergence (DAE). Reduction in crop height due to weed interference were 1.5, 8.1 and 10.5 cm for D_1, D_2, D_3, whereas, 8.3, 8.4, 5.4 and 4.8 cm for I_1, I_2, I_3 and I_4, respectively, in compared with control. Crop LAI reduced equally 174 cm^2 per each day delay in weed emergence time. Marigold could tolerate the effect of two weeds per meter of row at 10 DAE without any significant reduction in yield. Values of mean bias error, root mean square error and mean percentage error were calculated to be +0.1, 13.59 and 3.1%, respectively. It was concluded that the model of Cousens *et al*. was the best description for the yield of marigold at interference with lambsquarters.

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Key words: Crop height, Modeling, Weed competition.

1. Introduction

Marigold (*Calendula officinalis*) is a poor competitive plant against weeds especially during the earlier growth period and its production in Iran relies heavily on herbicides to control weeds (Omidbeigi, 2009; Mirshekari, 2012). Therefore if the weed problem is not managed properly, there is strong chance of crop failure (Massinga et al., 2001; Tabrizian et al., 2009). Development of weed management systems with a reduced dependency on herbicides requires new strategies based on improvements with respect to (1) prevention, (2) decision making and (3) weed control technology. Information on the time of weed emergence is necessary to develop effective models to predict the consequences of weed management in marigold (Dielman et al., 1995). Redroot pigweeds those emerged earlier than crop plants were taller and produced greater biomass than late emerging ones (Horak and Loughin, 2000). Ecophysiological simulation models for crop-weed competition simulate growth and production of species in mixtures, based on ecophysiological processes in plants and their response to the environment (Kropff et al., 1997). The objective of the present study was modeling of lambsquarters (*Chenopodium album*) competition in marigold field for better performance of weed controlling strategies.

2. Materials and Methods

A field experiment was conducted during 2010-2011 at Tabriz, (Lat. 38°, 5′; Long. 46°, 17′ and elevation 1360 m), Iran, in a sandy loam soil with pH of 7.7 and organic matter of 1%. Tabriz located at the north-west of Iran, and the climate is semi-arid. The experimental field had been in a potato-corn rotation cycle for the last two years. The experimental area was ploughed in the fall and manured with 12 t ha^{-1}. Fields were cultivated, disked, furrowed and then plotted in the early spring before sowing the seeds. Fertilizers used, in spring and before sowing, were 120 and 65 kg ha^{-1} of ammonium phosphate and urea, respectively. The plots were 3 by 3 m^{-2}. Studied treatments were lambsquaters densities (D_1= 2, D_2= 4 and D_3= 6 plants/meter of row) and its emergence times (I_1= simultaneously with marigold, I_2= 10, I_3= 20 and I_4= 30 days after crop emergence "DAE"). The relationship between lambsquaters density and marigold yield loss was described by the equation 1 (Cousens, 1985):

$$YL=(I.d)/[1+(I.d)/A] \quad (1),$$

Where YL=crop yield loss (%), d=weed density ($weeds/m^2$), I=crop yield loss percent per unit weed density as d approaches zero, and A=crop yield loss percent as d approaches infinity. To determine the relationship between weed density and emergence time with crop yield, equation 2 was used (Cousens et al., 1987):

$$Y=Y_{WF}(1-I.d/100(Exp(c*t)+(I.d)/A)) \quad (2),$$

Where Y=crop yield (kg ha^{-1}), Y_{WF} is estimated crop yield in weed-free plots, t=relative time of weed emergence, c=regression parameter that expresses the variation of the competitiveness of the weed depending on delaying in emergence and d, I and A described in equation 1.

3. Results and Discussion

The weed competition caused a significant reduction in the height of marigold at flowering stage (Fig. 1). Reduction in crop height were 1.5, 8.1 and 10.5 cm for D_1, D_2, D_3, whereas, 8.3, 8.4, 5.4 and 4.8 cm for I_1, I_2, I_3 and I_4, respectively, in compared with control. It seems that weed density is more effective than its emergence time, as Wiley and Hill (2008) emphasized on it in *Matricaria chamomilla*, as a short height medicinal plant. Effect of weed competition on anthodium diameter in marigold had similar trend to stem height (Fig. 3). Based on Wiley and Hill (2008) reports, there is a significant correlation (r=0.79) between crop height and anthodium diameter.

Crop LAI decreased significantly when weed density increased and emerged simultaneously with crop. Per each day delay in weed emergence time crop LAI reduction at D_0-D_1, D_1-D_2 and D_2-D_3 was calculated to be 77.5,100 and 345 cm^2 per unit area, respectively (Fig. 2). It was revealed that lambsquarters is a good competitor weed with marigold, especially in higher densities.

Marigold could tolerate two weeds per meter of row at 10 DAE without any significant reduction in flower yield (Fig. 4). In this study significant difference in crop yield due to weed density was expected, as weed density is a main factor in crop yield loss (Miri and Ghadiri, 2009). Otherwise, this can be explained on the base of crop shorter stature, which favored the competitiveness of lambsquarters. Knezevic *et al*. (Knezevic et al., 1997) reported that yield loss in tall and short sorghum cultivars at interference with pigweed were 16% and 75%, respectively.

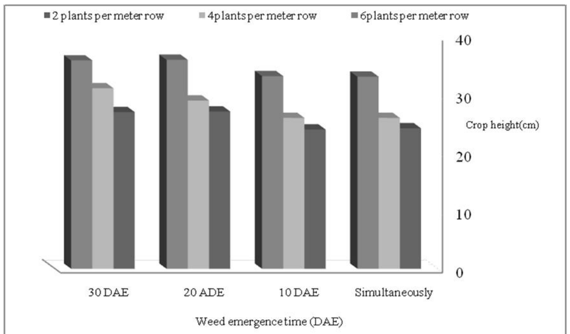

Figure 1. Effects of weed density and emergence time on crop height.

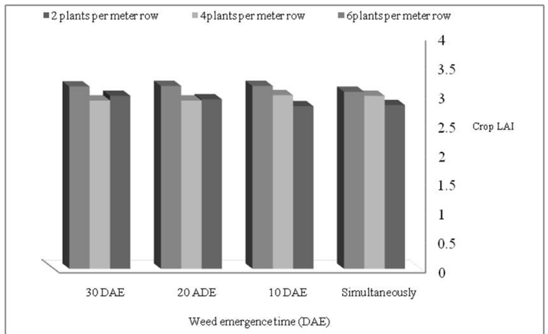

Figure 2. Effects of weed density and emergence time on crop LAI.

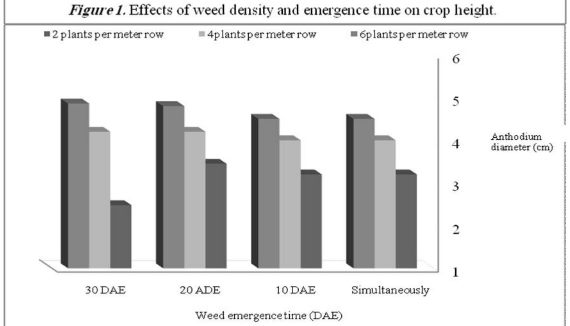

Figure 3. Effects of weed density and emergence time on anthodium diameter.

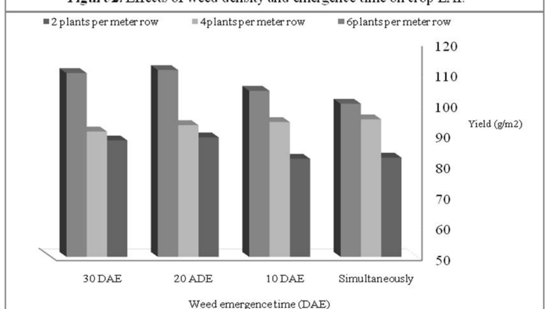

Figure 4. Effects of weed density and emergence time on marigold yield.

On the base of Cousens *et al*. (1987) model, correlation between observed and estimated yield values was 0.91. Values of mean bias error (MBE), root mean square error (RMSE) and mean percentage error (MPE) were calculated to be +0.10, 13.59 and 3.10%, respectively. With regarding reduction in RMSE value in this model in compared with Cousens (1985) model, it seems that, this model was the best description for marigold yield (Fig. 5). Besides, as reported by Bosnic and Swanton[1], if SE values of model parameters were lower than half of the parameter main value, as we resulted in this study (Table 1), the model had a higher validity for crop yield estimation. It was concluded that the model of Cousens *et al*. (1987) was the best description for the yield of marigold at interference with lambsquarters.

Table 1. Estimated coefficients, standard error (SE) and asymptotic 95% confidence intervals of two parameters model of Cousens *et al*.[3].

Parameter	Estimate (±SE)	Asymptotic	Asymptotic 95% confidence intervals	
			Lower	Upper
I	1.02(±0.40)	0.40	0.62	1.42
A	28.11(±2.98)	2.98	25.13	31.09
C	0.40(±0.008)	0.008	0.39	0.41

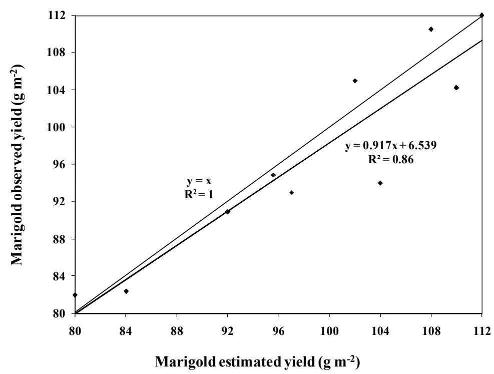

Figure 5. Marigold observed and estimated yields by the model of Cousens et al.[3], YL= 113[1-1.02d/100(Exp(0.40*t)+(1.02d)/28.11)]

Acknowledgements

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