Effect of *Acalypha australis* occurrence on soybean growth and the economic threshold level of *A. australis*

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Summary A field experiment was conducted to predict the reduction rate of soybean yield caused by the competing *Acalypha australis* and to establish the economic threshold of *Acalypha australis* L. for soybean (*Glycine max* (L.) Merr.) cultivation. The relationship between weed density and soybean yield was established as $Y = 415.5/(1 + 0.003356X)$ and the reduction rate of soybean yield was predicted from this equation. Compared with weed-free conditions, the rate of soybean yield reduction was calculated at 17–29% when the density of *Acalypha australis* was 60–120 plants m^{-2}. The economic threshold level of *Acalypha australis* for soybean cultivation was established as 6.3 plants m^{-2} from the Cousens' equation.

Keywords Competition, weed.

INTRODUCTION

Plant competition is commonly defined as the mutually adverse effects of plants which utilise the same resources which are in short supply. Competition occurs only when the resources are below combined demands. The competitive ability of a species is then determined by the capacity to capture and exploit resources rapidly. Worldwide, a 10% loss of agricultural production can be attributed to the competitive effect of weeds, in spite of intensive weed control in most agricultural systems(Acker 1993, Barrenyine 1974). Without weed control, yield losses could range from 10–100%, depending on the competitive ability of the crop. *Acalypha australis* is also one of the most important weed species in soybean (*Glycine max* (L.) Merr.) crops in Korea (Guh *et al.* 1978, Han *et al.* 2000, Kim *et al.* 2005). Is a herbaceous annual weed, growing 20–50 cm tall. This study was conducted to investigate the effect of *Acalypha australis* L. occurrence on the growth and yield of soybean, to predict the reduction rate of soybean yield caused by its competing with *A. australis* and to establish the economic threshold of *A. australis* for soybean cultivation (Kim *et al.* 1984, Kim *et al.* 1995).

MATERIALS AND METHODS

Field experiment A field experiment was conducted to evaluate the competitive effects of *Acalypha australis* occurrence on the growth and yield of soybean, and to predict the reduction rate of soybean yield caused by competing with *A. australis*. The experiment was conducted in Suwon in 2008. The experiment consisted of three replicates in a randomised block design. The plot size was 2.2 × 2.7 m, that is a total area is 248.5 m^2. An $N–P_20_5–K_20$ basal fertiliser was applied at a rate of 4–7–6 kg 10 a^{-1} before sowing.

Prediction model and statistical analyses Soybean yields were fitted to the following rectangular hyperbola equation (Cousens 1985a), to estimate parameters for predicting yields as a function of weed density as follows : $Y = Yo/(1 + \beta X)$ where Yo is the weed-free soybean yield (t ha^{-1}): β is a measure of weed competitiveness (a weed density of $1/\beta$ reduces the soybean yield by 50%) and X is weed density.

Economic thresholds (ET) of *Acalypha australis* were estimated by equating – the cost of controlling – the weed with the value of soybean yield gained by herbicide application. Calculation was based on the equation developed by Cousens (1985b) as follows :

$$ET = Cw/(Y \times P \times L \times K)$$

where Cw is herbicide cost; Y is weed-free soybean yield (t ha^{-1}); P is value per unit of weed density; L is proportional loss per unit of weed density; and H is herbicide efficacy, a proportional reduction in weed density or weed biomass by the herbicide treatment. The labour time to control weeds in the soybean field was applied 4 h according to guidelines of the Rural Development Administration (2003, 2005, 2007). All statistical analyses were conducted using Genstat (Genstat Committee 2002).

RESULTS AND DISCUSSION

Competition of soybean with the weed As the density of *A. australis* increase from 4 to 256 plants m^{-2}, the height and stem length of soybean not affected 60 days after sowing (Table 1). The lack of competitive affects of *A. australis* soybean was mainly caused by early weed growth characters (Lee *et al.* 1982).

The yield of soybean decreased with increased *Acalypha australis* density, 11−51% as when compared with weed-free (Table 2). This indicated that competition of the soybean with the weed resulted in a higher yield reduction rather than growth reductions during vegetation period (Table 1).

Table 1. Changes in height and dry weight of soybean at vegetation period, depending on the density of *Acalypha australis*.

	Plant height (cm)			Dry weight (g per two plants)	
Density (No. m^{-2})	30 DAS[a]	45 DAS	60 DAS	45 DAS	60 DAS
0	44.6a[b]	89.6a	132.4a	25.7a	41.1a
4	49.6a	92.6a	129.7a	28.2a	36.5a
32	46.8a	91.9a	130.8a	24.6a	41.4a
64	47.4a	92.2a	135.6a	25.1a	39.6a
128	43.3a	88.7a	128.1a	27.5a	37.3a
256	47.7a	91.0a	134.7a	24.1a	37.5a

[a] DAS : days after sowing.
[b] Means within columns followed by the same letter were not significantly different at P = 0.05.

Table 2. Yields and yield constituents of soybean depending on the density of *Acalypha australis*.

Density (No. m^{-2})	Pod (No. per one plant)	Weight of 100 seeds (g)	Yield (kg 10 a^{-1})	Yield index (%)
0	82.4a[a]	31.7a	439.2a	–
4	73.6a	32.1a	392.1b	89.3
32	55.1b	32.1a	361.5bc	82.3
64	58.8b	32.5a	339.7cd	77.3
128	32.8c	31.9a	308.3d	70.2
256	21.6c	30.4b	215.7e	49.1

[a] Means within columns followed by the same letter were not significantly different at P = 0.05.

Prediction of soybean yields The relationship between weed density and soybean yield was established as Y = 415.5/(1 + 0.003356X) with the reduced rate of soybean yield were predicted from this equation (Figure 1).

Compared with the weed-free control, the reduction rate of soybean yield was calculated as 0.3–9%, 17–29%, and 40–46% when the density of *A. australis* were 1–30, 60–120, and 200–250 plants m^{-2}, respectively (Table 3).

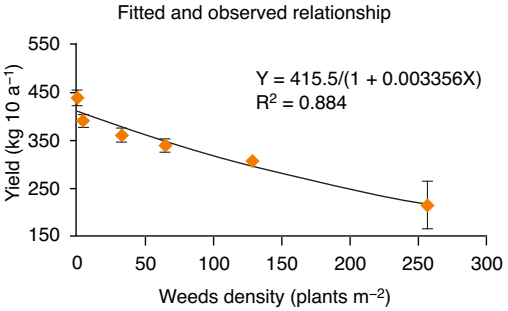

Figure. 1. Estimated curve fitting and observed soybean yields from a nonlinear regression analysis using Cousens' hyperbolic model depending on the density of *Acalypha australis*.

Table 3. Estimation of yields and reduction rates of soybean from non linear regression depending on the density of *Acalypha australis.*

Density (No. m^{-2})	1	30	60	120	200	250
Yield (kg 10 a^{-1})	414.1	377.5	345.9	296.2	248.6	225.9
Reduction rate (%)	0.3	9.1	16.8	28.7	40.2	45.6

Estimation of economic thresholds The economic threshold level (ET) of *A. australis* for soybean cultivation was established as 6.3 plants m^{-2} from the Cousens' equation (Table 4). Therefore, the ET levels of *A. australis* can be used to support decision-making on whether to apply this herbicide application for weed management in soybean crop.

The height and stem length of soybean were not affected by the competition with *A. australis*, during the crop vegetative period, however, the yield of soybean

Table 4. Parameter estimates and economic threshold of *Acalypha australis* L. for soybean cultivation.

C_w[a] (won)	Y[b] (kg 10a^{-1})	P[c] (won kg^{-1})	L[d] (%)	K[e]	ET[f] (No. m^{-2})
30,272	415.5	3,651	0.003356	0.95	6.3

[a] cost for weeding;
[b] yield of the weed free crop;
[c] price of soybean;
[d] reduction rate of yield per one *Acalypha australis* L. plant;
[e] efficacy of weeding (efficacy/100);
[f] economic threshold = Cw/(Yx Px Lx K).

was decreased compared with weed-free control. The relationship between weed density and soybean yield was established as $Y = 415.5/(1 + 0.003356X)$ and the economic threshold level of *A. australis* for soybean cultivation was established as 6.3 plants m^{-2}. The rectangular hyperbola model as proposed by Cousens (1985a) effectively described the competitive relationships between the weeds and soybean, successfully predicted soybean yields as a function of weed density and allowed the estimation of ET values.

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