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Full Length Research Paper

Sesame (*Sesamum indicum* L.) yield loss estimation with common cocklebur (*Xanthium strumarium* L.) interference

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Common cocklebur (*Xanthium strumarium* L.) is the most prevalent weed for sesame in Turkey. Sesame yield decreased by the increasing densities of common cocklebur. The asymptotic weed-free yield of sesame was 1863 kg ha^{-1} in 2005 and 1931 kg ha^{-1} in 2006, while the yield was estimated to be 239 and 424 kg ha^{-1} at the 7 plant m^{-1} crop row of common cocklebur density in 2005 and 2006, respectively. Common cocklebur dry biomass per plant decreased as the weed density increased, while total weed dry biomass per meter of crop row increased with the weed density. The sesame yield was adversely affected by common cocklebur dry biomass accumulation.

Key words: Sesame, common cocklebur, yield, biomass.

INTRODUCTION

Sesame (*Sesamum indicum* L.), which originated from tropical Africa and usually grown in arid and semi arid regions, is a high value food crop with high oil content, roughly about 50% of seed weight which makes it a good source of edible oil. Sesame is utilized as a nutritious food and confectionary seeds (Grichar et al., 2001a).

Turkey is among the foremost producers of sesame (Oplinger et al., 1997). Sesame can be included in almost all crop rotations in favorable areas because of its short growing period, high value in market and low production cost (Işler et al., 1996). Turkey has 43.000 ha sesame cultivation areas and 23.000 tones production (Koca et al., 2007; Uzun et al., 2007; Saydut et al., 2008).

The sesame plant is very sensitive to environmental conditions and abiotic stress factors, which cause generally quantitative and/or qualitative decline in yield (Uçan et al., 2007). Slower growth at earlier growing stages makes sesame plants poor competitors against weeds, which usually grow faster than crop plants and compete for the soil moisture, nutrients and other resources (Oplinger et al., 1997). Weed-induced reductions of sesame yield up to 135% from weeds competition (Grichar et al., 2001b). Weed competition may prove fatal to the sesame (Americanos, 1994).

Weeds can form six times more biomass than sesame at 48 days after planting (Eagleton et al., 1987; Bennett, 1993). Limited or lack of weed control options in sesame production makes weeds more troublesome. There is no known registered post emergence herbicide for sesame in Turkey (Yücer, 2007). However, fibrous root system of sesame limits mechanical control measures, and many herbicides give erratic results (Oplinger et al., 1997).

Common cocklebur is a common, competitive and vigorous weed in most summer crops (Holm et al., 1991). Bükün et al. (2005) reported that *Xanthium strumarium* was the most prevalent weed species and produced the highest biomass.

Shipley and Weis (1969) reported that common cocklebur requires large amounts of the nitrogen, phosphorus and potassium for growth. Common cocklebur may grow up to heights of 150 cm and has a root depth and radius of 2.9 and 4.3 m, respectively (Davis et al., 1967). Competition studies showed that common cocklebur reduces the yield of a number of important crops. Two common cocklebur plants in 15 m^{-1} of row reduced cotton yield by 17% (Snipes et al., 1987). Peanut yield reduction ranged from 0 to 88% for common cocklebur densities of 0 to 32 per 8 m^{-1} of row (Royal et al., 1997). Increased densities of common cocklebur reduced soybean seed yield, total dry weight and number of pod per plant (Bloomberg et al., 1982). Under full-season competition, one common cocklebur per 3 m^{-1} of row reduced soybean seed yield by 3 to 12%.

There is limited information in the literature on weed competition in sesame crop. Effects of common cocklebur densities, on sesame yield and density dependent common cocklebur's biomass accumulation is presented in this paper.

MATERIALS AND METHODS

Experimental area and design

Field studies were conducted in experimental fields of College of Agriculture, Harran University, Sanliurfa, Turkey in 2005 and 2006. The soil was silty-clay with 1 to 1.2% organic matter and pH 7.5 to 7.6. The soil was plowed and disked prior to planting of sesame. A standard species of the region (27206, a breeding line) was sown by hand and fertilizer was applied at a rate of 60 kg ha^{-1} N, and 60 kg ha^{-1} P_2O_5 on June 8, 2005 and June 5, 2006. Sesame plants were irrigated by sprinkler just after sowing to ensure uniform germination and irrigation was done every week during growing season. Weeds were thinned at 20 cm intra row after emerging. Fertilizer was applied again at 60 kg ha^{-1} N rate at the beginning of flowering stage of sesame. Plots consisted of 6 rows, which were 4 m long and spaced 70 cm apart. The experimental design was randomized complete block with three replications. Naturally occurring populations of common cocklebur were dense enough to establish the experiments in desired densities. Cocklebur plants were thinned to desired densities of 0, 1, 3, 4, 6, 10, 14 and 28 plants per 4 m of crop row. These were equivalent to 0, 0.25, 0.75, 1, 1.50, 2.50, 3.50 and 7.00 plants m^{-1} of row. Undesirable weeds were removed by hand on bed tops in three days interval. At the end of the growing season, five common cocklebur plants from each plot were clipped at the soil level, fresh weight was obtained and then they were dried at 70°C for 48 h to determine plant dry biomass. Before sesame harvest, the remaining common cockleburs were cut at ground level and removed from plots to facilitate sesame harvest. Sesame plants in the two middle rows of each plot were hand harvested at the end of September, left in the field for air drying for 2 weeks, and then threshed followed by weighing to obtain seed yield.

Statistical analysis

Sesame yield and cocklebur biomass accumulation data were done using ANOVA and PROC GLM procedure in SAS (SAS, 2009). Then, the relationships between common cocklebur density and sesame yield; common cocklebur density and its biomass; and common cocklebur biomass and sesame yield were analyzed at PROC NLMIXED procedure in SAS (SAS, 2009). The cocklebur density and sesame yield data fitted Cousens' (1985) hyperbolic crop yield loss relationship function:

$$Y_s = Y_{wf}\left[1 - \frac{ID}{100\left(1 + \frac{ID}{A}\right)}\right] \quad (1)$$

Where, Y_s is the observed sesame yield (kg ha^{-1}); D is the cocklebur density (plants per m^{-2}); Y_{wf} is the estimated weed-free yield and parameter I is the percent yield loss per unit weed density as D approaches 0, A asymptotic percent yield loss as D approaches infinity.

A non-linear logistic function (Sit and Costello, 1994) was fitted to relationship between cocklebur biomass and the weed densities:

$$Y_{dw} = \frac{a}{(1 + b * \exp(-c * d))} \quad (2)$$

Where, Y_{dw} is the dry weight per cocklebur plant (g); a is the Y-intercept, b and c the asymptote of curve; d is the densities of common cocklebur per meter crop row.

The relationship between the sesame yield and common cocklebur biomass accumulation is modeled as:

$$Y_s = K \exp\left(M * C_b\right) \quad (3)$$

Where, Y_s is the observed sesame yield (kg ha^{-1}); K is the asymptotic yield; M is parameter and C_b stands for common cocklebur biomass accumulation g per plant.

RESULTS AND DISCUSSION

Irrigation stimulated common cocklebur emergence four days earlier than sesame which helps to make it more competitive and cause significant crop yield reduction.

Common cocklebur density and sesame yield relation was calculated for both years separately because year effect was statistically significant. Crop yield significantly responded to varying cocklebur densities at 5% probability level. The hyperbolic model (Equation 1) fitted satisfactorily to the relationship between common cocklebur densities and sesame yields. Forcing parameters I and A equal zero in the sesame yield function, the asymptotic weed free yield was estimated to be 1863 and 1931 kg ha^{-1} in 2005 and 2006 (Table 1), respectively while observed weed free yields were 1617 and 1650 kg ha^{-1}. Parameter I as the weed density approaches 0 and has a significantly positive effect on the sesame yield (Table 1).

Asymptotic percent yield loss coefficient, A, as D approaches infinity contributes significantly positive effect to the sesame yield. Increasing common cocklebur densities decreased sesame yields (Figure 1).

The observed sesame yield was 1447 and 1497 kg ha^{-1} at the 0.25 plant m^{-1} crop row of common cocklebur density, and with increasing common cocklebur density to 7 plant m^{-1} crop row, sesame yield decreased to 239 and 424 kg ha^{-1} in 2005 and 2006, respectively. The negative relationship between weed density and crop yield was consistent with earlier studies (Weaver, 1991; Cowbrough et al., 2003; Thomas et al., 2004). Since year effect was not significant on dry biomass accumulation per plant, data were pooled for two years. A negative relationship

Table 1. Parameters estimates for actual sesame yield with weed density.

Variables	Estimates		t-value		P>|t|	
	2005	2006	2005	2006	2005	2006
Y_{wf}	1862.7	1931.4	27.8	9.8	<.0001	<.0001
I	111.6	116.5	11.8	3.1	<.0001	0.0134
A	98.5	89.1	46.9	19.4	<.0001	<.0001

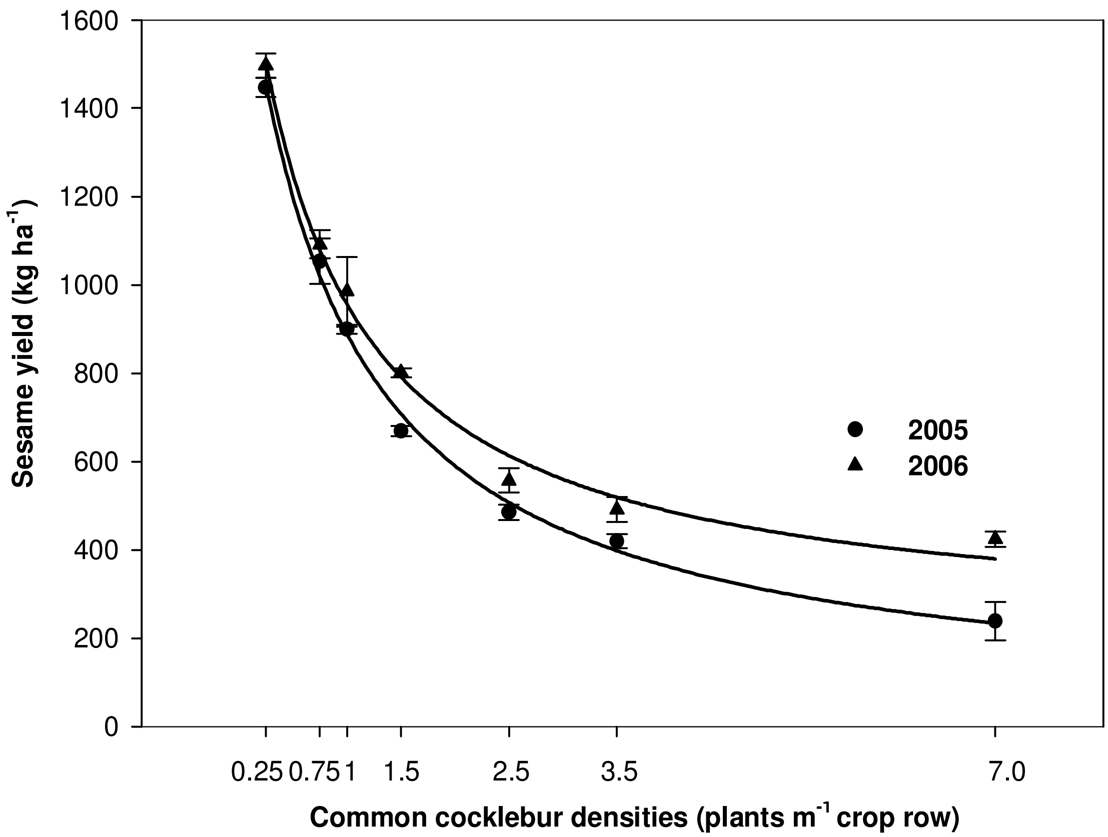

Figure 1. Sesame yield reduction with increasing common cocklebur densities. Data points are means and standard errors

between common cocklebur density and their dry biomass accumulation per plant was found. The parameters *a*, *b* and *c* in the biomass model, which are a function of the weed density were statistically significant at 5% level (Equation 3). Forcing b parameter equals zero, the asymptotic biomass accumulation would be 86.4 g plant^{-1} (Table 2).

As the weed density per m^{-2} increases, the biomass accumulation per plant (g) in m^{-2} decreases. Our findings are in agreement with earlier research that common cocklebur dry biomass accumulation per plant decreased as weed density increased. (Bridges and Chandler, 1987; Buchanan et al., 1982; Cardina and Brecke, 1989; Clewis et al., 2001; Royal et al., 1997; Rushing et al., 1985; Snipes et al., 1982; Weaver, 1991; Clewis et al., 2001). Observed common cocklebur dry biomass was 230.3 g per plant at 0.25 plant m^{-1} crop row and 124.8 g per plant at density of 7 plants m^{-1} crop row (Figure 2). The negative relationship between the common cocklebur biomass accumulation and their density is evidence from the intraspecific competition (Figure 2).Effect of total cocklebur dry biomass on sesame yield is depended on year, thus data was calculated separately for each year. Parameter estimates *K* and *M* in sesame yield as a function of the common cocklebur biomass accumulation were statistically significant at 5% level (Table 3).

Table 2. Parameters estimates for dry biomass accumulation with weed density.

Variables	Estimates	t-value	P>|t|
a	86.4	1.2	0.24
b	-0.6	-2.2	0.04
c	0.1	0.6	0.56

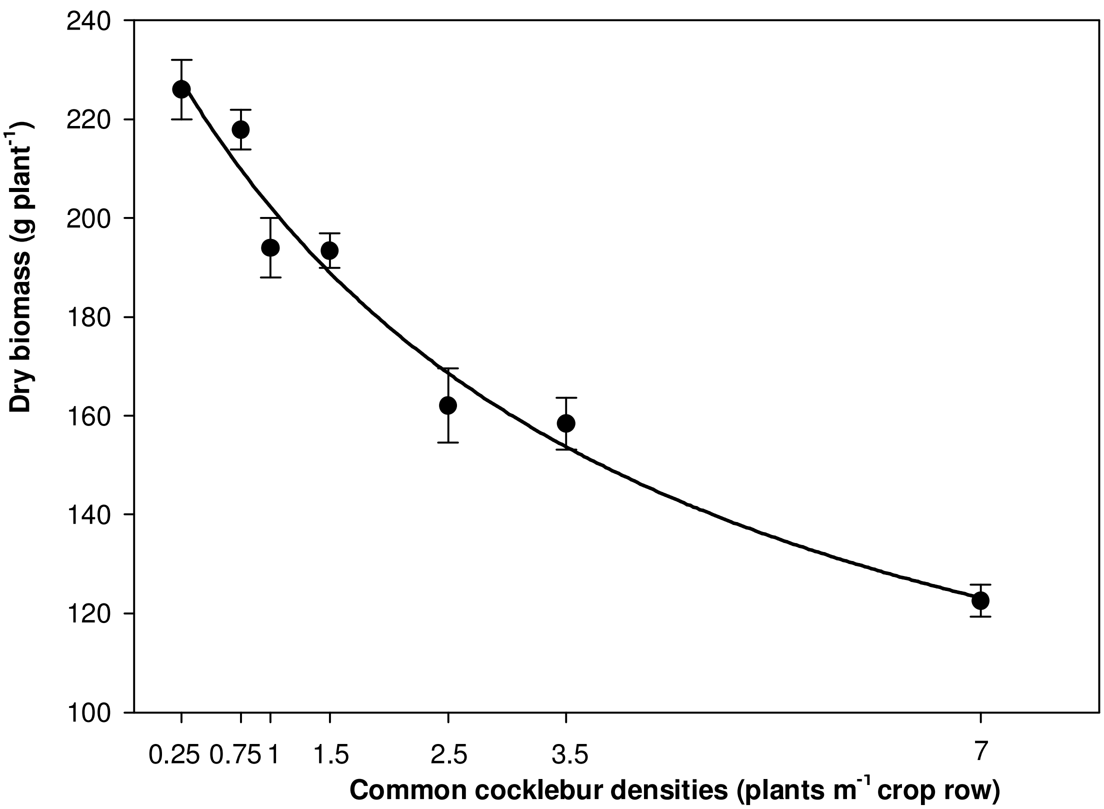

Figure 2. Common cocklebur density and their dry biomass accumulation per plant. Data points are means and standard errors.

Table 3. Parameters estimates for actual sesame yield with weed biomass.

Variables	Estimates		t-value		P>|t|	
	2005	2006	2005	2006	2005	2006
K	1627.8	1620.8	53.4	26.4	<.0001	<.0001
M	-0.0027	-0.0022	-25.6	-11.3	<.0001	<.0001

Asymptotic weed-free yield of sesame were calculated to be 1627.8 and 1620.8 kg ha^{-1} in 2005 and 2006, respectively (Table 3 and Figure 3). Sesame yield decreased with increasing common cocklebur biomass (g m^{-1} crop row). Sesame yield was 1447 and 1497 kg ha^{-1} at 57 and 58.3 g m^{-1} crop row of common cocklebur biomass accumulation in 2005 and 2006, respectively. Crop yield was decreased to 239 kg ha^{-1} when total dry biomass accumulation was 858 g m^{-1} crop row in 2005 and 424 kg ha^{-1} at 884.3 g per m^{-1} crop row of common cocklebur dry biomass accumulation in 2006 (Figure 3). Based on the results, common cocklebur due to its very strong and competitive characteristics even at low density can significantly reduce sesame yield and produce high

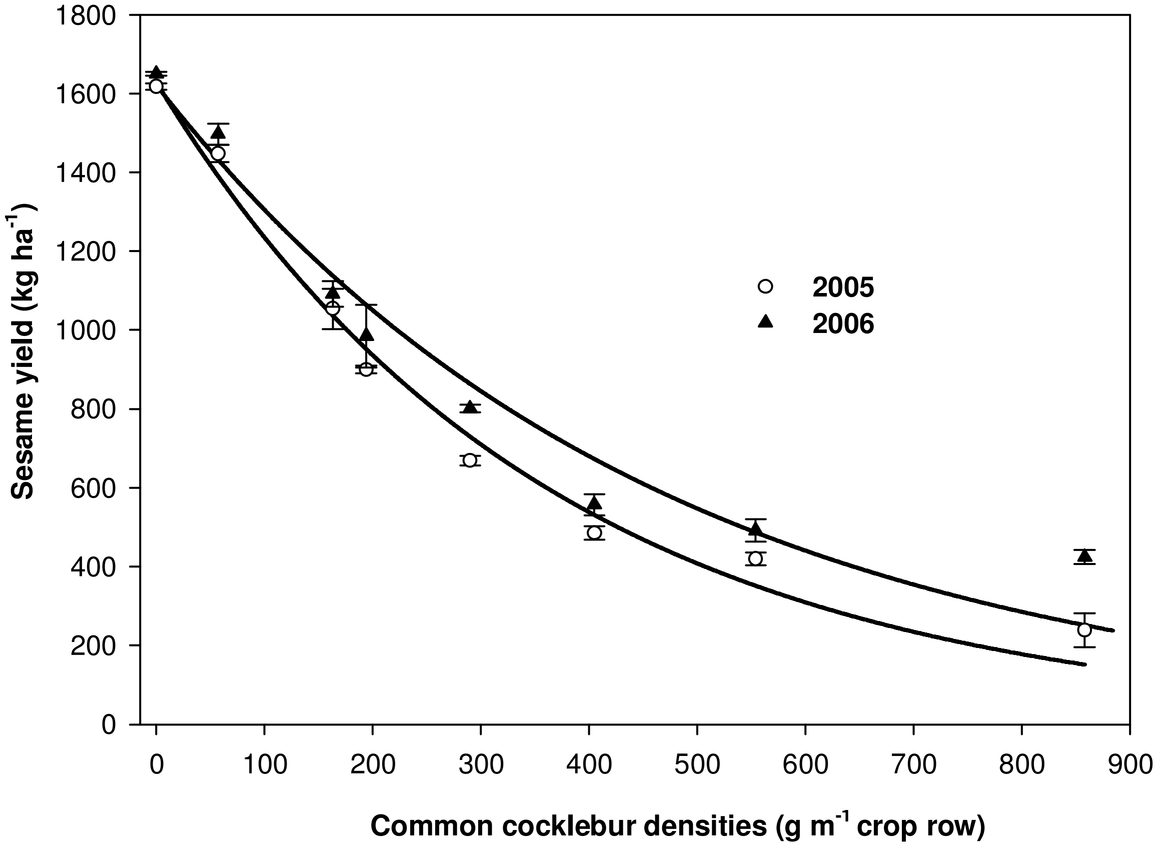

Figure 3. Sesame yield and common cocklebur relation for both years. Data points are means and standard errors.

dry biomass. Sesame is a valuable crop for producers, thereby, even small amount of yield reduction will cause high economic loss. To prevent yield losses, an effective weed control methods should be implemented for common cocklebur in irrigated sesame growing areas.

REFERENCES

Americanos PG (1994). Weed Management in oil Crops. Pages 331-338. In FAO Plant Protection Paper, FAO Rome, Italy.

Bennett M (1993). Sesame Research Report 1991-1992. Wet season, Technical Bulletin No. 215. Northern Territory, Australian Department of Primary Industries and Fisheries, Katherine, AUS.

Bloomberg JR, Kirkpatrick BL, Wax LM (1982). Competition of common cocklebur (*Xanthium strumarium*) with soybean (*Glycine max*). Weed Sci. 30: 507-513.

Bridges DC, Chandler JM (1987). Influence of Johnsongrass (*Sorghum halepense*) density and period of competition on cotton yield. Weed Sci. 35: 63-67.

Buchanan GA, Murray DS, Hauser EW (1982). Weeds and their control in peanuts. In: Peanut Science and Technology (eds Pattee HE & Young CT) American Peanut Research and Education Society. p. 5. Yoakum, Tx, USA.

Bükün B, Boydak, E, Yücel E, Deme M (2005). Determination of Weeds and Their Biomass in Irrigated Sesame (*Sesamum indicum* L.). Harran Univ. J. Fac. Agric., 9(1): 31-35.

Cardina J, Brecke BJ (1989). Growth and development of Florida beggarweed (*Desmodium tortuosum*) selections. Weed Sci. 37: 207-210.

Clewis SB, Askew SD, Wilcut JW (2001). Common ragweed interference in peanut. Weed Sci. 49: 768-772.

Cousens R (1985). A simple model relating yield loss to weed density. Ann. Appl. Biol. 107: 239-252.

Cowbrough MJ, Brown RB, Tardif FJ (2003). Impact of common ragweed (*Ambrosia artemisiifolia*) aggregation on economic thresholds in soybean. Weed Sci. 51: 947-954.

Davis RG, Johnson WC, Wood FO (1967). Weed root profiles. Agron. J. 59: 555-558.

Eagleton G, Sandover S, Dickson M (1987). Research report: sesame seed 1982-1986. Department of Agriculture. Kununurra, West Australia.

Grichar WJ, Sestak DC, Brewer KD, Besler BA, Stichler CR, Smith DT (2001a). Sesame (*Sesamum indicum* L.) tolerance and weed control with soil-applied herbicides. Crop Prot. 20(5): 389-394.

Grichar WJ, Sestak DC, Brewer KD, Besler BA, Stichler CR, Smith DT (2001b). Sesame (*Sesamum indicum* L.) tolerance with various postemergence herbicides Crop Prot. 20(8): 685-689

Holm LG, Plucknett DL, Pancho JV, Herberger JP (1991). The World's Worst Weeds, Distribution and Biology. The University Press of Hawaii.

İşler N, Arıoğlu HH, Boydak E, Hacıkamiloğlu İ (1996). Şanlıurfa koşullarında II.ürün olarak yetiştirilebilecek bazı susam çeşitlerinin önemli tarımsal ve bitkisel özelliklerinin belirlenmesi (Determination agronomic and plant properties of some sesame species as grown second crop in Şanlıurfa conditions). Çukurova Univ. J. Agric. 11(1):

39-50.
Koca H, Bor M, Özdemir F, Türkan İ (2007). The effect of salt stress on lipid peroxidation, antioxidative enzymes and proline content of sesame cultivars. Environ. Exp. Bot. 60: 344-351.
Oplinger ES, Putnam DH, Kaminski AR, Hanson CV, Oelke EA, Schulte EE, Doll JD (1997). Sesame Alternative Field Crops Manual, Web-site, http://www.hort.purdue.edu/newcrop/afcm/sesame.html (Last visited at 15.08.2011)
Royal SS, Brecke BJ, Colvin DL (1997). Common cocklebur (*Xanthium strumarium*) interference with peanut (*Arachis hypogaea*). Weed Sci. 45: 38–43.
Rushing DW, Murray DS, Verhalen LM (1985). Weed interference with cotton (*Gossypium hirsutum*). II. Tumble pigweed (*Amaranthus albus*). Weed Sci. 33: 815-818.
SAS Institute Inc. (2009). SAS OnlineDoc 9.1.3. Cary, NC: SAS Institute.
Saydut A, Duz MZ, Kaya C, Kafadar AB, Hamamci C (2008). Transesterified sesame (*Sesamum indicum* L.) seed oil as a biodiesel fuel. Bioresour. Technol. 99: 6656-6660.
Shipley JL, Weise AF (1969). Economics of weed control in sorghum and wheat. Texas Agriculture Experimental Station Miscellaneous Publication. No.909. 8 pp. TX, USA.
Sit V, Costello MP (1994). Catalog of Curves for Curve Fitting. Biometrics information *Handbook Series*, Ministry of Forests, Victoria, BC. Canada. ISSN 1183-9759; No.4.
Snipes CE, Buchanan GA, Street JE, McGuire JA (1982). Competition of common cocklebur (*Xanthium pensylvanicum*) with cotton (*Gossypium hirsutum*). Weed Sci. 30: 553–556.
Snipes CE, Street JE, Walker RH (1987). Interference periods of common cocklebur (*Xanthium strumarium*) with cotton (*Gossypium hirsutum*). Weed Sci. 35: 529-532.
Thomas WE, Askew SD, Wilcut JW (2004). Tropic croton interference in peanut. Weed Technol. 18: 119-123.
Uçan K, Kıllı F, Genç C, Merdun H (2007). Effect of irrigation frequency and amount on water use efficiency and yield of sesame (*Sesamum indicum* L.) under field conditions. Field Crop. Res. 101: 249–258.
Uzun B, Arslan C, Karhan M, Toker C (2007). Fat and fatty acids of white lupin (*Lupinus albus* L.) in comparison to sesame (*Sesamum indicum* L.). Food Chemist. 102: 45-49.
Weaver SE (1991). Size-dependent thresholds for three broadleaf weed species in soybeans. Weed Technol. 5: 674-679.
Yücer, MM (2007). Registered agrochemicals in Turkey. Hasad Yayıncılık, Ankara. p. 315.