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Effects of Weed-free Period on Seed Yield and Yield Components of Double-cropped Soybean (*Glycine max* L.)

[1]Mehmet Arslan, [2]Ilhan Uremis and [3]Ahmet Uludag
[1]Department of Field Crops, [2]Department of Plant Protection, Faculty of Agriculture, Mustafa Kemal University, Hatay, Turkey
[3]Plant Protection Research Institute, Bornova-Izmir, Turkey

Abstract: Maintaining weed-free period longer than required for optimum seed yield increases cost of crop production. A two-year study was conducted to determine the critical weed-free period for double-cropped soybean to obtain maximum seed yield. The experimental design was Randomized Complete Blocks with three replications. Seed yield varied between 1289.3 and 4778.3 kg ha^{-1} in 2002 and between 1007.3 and 3980.0 kg ha^{-1} in 2003. The highest and the lowest seed yield were obtained from weed-free and weedy control treatments, respectively in both years. Seed yield exponentially increased with the increasing weed-free period in 2002 and 2003. Seed yield increase in increased period of weed-free plots was resulted from increased pod and seed number/plant. The result of present study showed that double-cropped soybean must be kept weed-free from emergence till physiological maturity to obtain maximum seed yield.

Key words: Competition, weed-free period, soybean, yield, yield components

INTRODUCTION

Soybean is successfully produced after small grain harvest as a double-crop in the Mediterranean region of Turkey. However, soybean planting acreage tended to decrease due to low local crop price and high cost of production. Reduction in the cost of double-cropped soybean production increases soybean profitability. Cost of weed control, comprise between 20 and 30% of total input, varies among soybean fields. One-way to reduce cost of weed control is to build up an Integrated Weed Management (IWM) by the adequate timing of weed removal through determination of the critical period of weed removal. Integrated weed control systems involve the use of crop-weed interference research[1]. Weeds in double-cropped soybean fields can be successfully removed with the selection of proper selective postemergence herbicides. In addition to available selective postemergence herbicides, development of glyphosate-resistant soybean has allowed to use glyphosate (a nonselective herbicide) to control annual and perennial weeds[2-4]. The duration of weeds before the competition reduces soybean yield must be known to adopt an efficient herbicide program. The results of many weed soybean interference studies showed that weed interference duration and length of weed-free conditions vary with weed species and soybean cultivars used[5-9]. Most of the weed interference researches are conducted for full season cropped soybean and the knowledge for double cropped-soybean is very limited. Under double-cropped conditions, many summer weeds may have advantage for fast germination and growth. Consequently, the use of the knowledge of full season soybean weed interference studies may not be proper to build up an IWM for double-cropped soybean.

The purposes of this research were to determine the required weed-free period that double-cropped soybean needed for maximum crop yield.

MATERIALS AND METHODS

Field experiments were conducted in 2002 and 2003 at the Experimental Farm of Agricultural Faculty, Mustafa Kemal University in Hatay (36°39' N, 36°40' E; 83 m elevation), Turkey. The soil of the experimental site, developed from alluvial deposits of river terraces, is typical for the Eastern Mediterranean region in Turkey and is classified as Vertisol by FAO/UNESCO[10] having relatively high clay content with the predominant clay minerals smectite and kaolinite. The soil of the experimental plots was clay in texture (38.3% sand, 20.4% silt, 41.2% clay) with low organic matter

Corresponding Author: Dr. Mehmet Arslan, Department of Field Crops, Faculty of Agriculture, Mustafa Kemal University, Hatay, Turkey Tel: + 90 326 245 58 36 Fax: + 90 326 245 58 32 E-mail: marslan@mku.edu.tr

content (0.60%) and was slightly alkaline (pH 7.4) in reaction. The available total nitrogen, available phosphorus and potassium contents were 0.083%, 122.4 and 690 kg ha^{-1}, respectively. Mean air temperature was about 26°C at the cropping period (June-October) in both years, while the mean relative humidity was around 54% during the growing periods in both years.

The field was tilled twice with a cultivator and disk harrow, following wheat harvest in both years. The soybean cultivar A 3935 (Asgrow Seed Co.) was planted at a rate of 25 seeds in 1 meter row on June 13 and 29 in 2002 and 2003, respectively. Plots consisted of four 5 m rows, planted 0.65 m apart, that were end trimmed to final length of 5 m prior to harvest of the center two rows. The experimental design was Randomized Complete Block with 3 replications. In both years, seed germination and plant emergence were helped by light sprinkler irrigation. Flood irrigation method was applied every 15 days interval after emergence. At time of sowing, 25 kg ha^{-1} N and 25 kg ha^{-1} P_2O_5 were applied as a 20-20 fertiliser. Lambda-cyhalothrin applications of 2 L ha^{-1} were sprayed twice to control insect pests each year. Weed removal started a week after soybean germination and continued 11 weeks at weekly intervals. Weeds were allowed to interfere with soybean from emergence until a certain week, after which weeds were removed and plots maintained weed-free for the entire growing season. Also, season-long weedy (weedy control) and season-long weed-free plots (weed-free control) were maintained. Weeds were removed by hand and hand hoeing in all plots when required by the treatment.

Data was subjected to analysis of variance using the general linear models procedure in the Statistical Analysis System[11]. Means of measured plant parameters were compared by using Fisher's protected Least Significance Difference (LSD) at 95% level of probability. Simple correlations were obtained with the ANOVA procedure of SAS with the MANOVA option.

RESULTS AND DISCUSSION

In both years of the study, johnsongrass (*Sorghum halepense*) was the dominant weed species with the density of 39.7 and 34.4% in 2002 and 2003, respectively (Table 1). Common cocklebur (*Xanthium strumarium*) was the second dominant weed species followed by field bindweed (*Convolvulus arvensis*) and redroot pigweed (*Amaranthus retroflexus*).

Table 1: Weed species and their densities at the experimental plots in 2002 and 2003

	Weed density (%)	
Major weed species	2002	2003
Monocotylodenae		
Johnsongrass (*Sorghum halepense*)	39.7	34.4
Junglerice (*Echinochloa colonum*)	4.7	1.9
Dicotylodenae		
Common cocklebur (*Xanthium strumarium*)	18.7	21.0
Field bindweed (*Convolvulus arvensis*)	16.4	17.2
Redroot pigweed (*Amaranthus retroflexus*)	4.7	11.5
Common purslane (*Portulaca oleracea*)	4.7	3.8
Red amaranth (*Amaranthus hybridus*)	4.7	3.8
Cutleaf ground-cherry (*Physalis angulata*)	2.3	1.9
Venice mallow (*Hibiscus trionum*)	1.2	1.9
Common heliotrope (*Heliotropium europaeum*)	1.2	1.0
Tumble pigweed (*Amaranthus albus*)	0.7	-
Black nightshade (*Solanum nigrum*)	1.2	-
Malta jute (*Corchorus olitorius*)	-	0.6
Puncture evine (*Tribulus terrestris*)	-	0.6
Turnsoler weed (*Chrozophora tinctoria*)	-	0.6

Soybean plant height was significantly affected from the duration of weed-free period. Among treatments, plant height values varied between 78.13 and 52.60 cm in 2002 and 57.56 and 41.40 cm in 2003 (Table 2). The highest plant height was obtained from weed-free for 1 Week After Emergence (WAE) and weedy control plots in 2002 and 2003, respectively. The lowest plant height values were obtained from weed-free for 11 WAE plot in both years of the study. Soybean plant height decreased with the increasing weed-free period. Soybean grown in weedy control plots had significantly greater plant height than weed-free control plots due to weed crop competition for light. Plant height was significantly and negatively correlated with the seed yield (Table 3). However, Young *et al.*[6], Shurtleff and Coble[12], Krausz *et al.*[13] reported opposite results that weed competition throughout the growing season reduced the plant height. The negative correlation between plant height and seed yield was resulted from weed interference. Since plant grown in prolonged weedy plots had less radiation for carbohydrate production and they allocated most of their carbohydrates for vegetative parts to have an advantage for light interception. Consequently, soybean grown in prolonged weedy plots had fewer number of pods/plant than plant grown in weed-free plots.

Branch number/plant was significantly affected from the duration of weed-free period. Branch number/plant values varied between 3.73 and 1.86 in 2002 and 3.60 and 2.13 in 2003. Branch number/plant increased with the increasing duration of weed-free period in both years. Branch number/plant was positively and significantly correlated with seed yield, pod number/plant, seed number/plant, seed weight and seed yield (Table 2).

Node number/plant was one of the less affected plant parameters from the duration of weed-free period. Node number values varied between 11.06 and 16.13 plant^{-1} in both year of the study. Number of reproductive node significantly affects the seed yield (Table 2).

Table 2: Effects of duration of weed-free period on seed yield and yield components of double-cropped soybean

	Plant height (cm)		Branch number/plant		Node number/plant		Pod number/plant		Seed number number/plant		Seed weight (g^{-1})		Seed yield (kg ha^{-1})	
Treatments	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Weedy control	69.73	57.56	1.86	2.13	14.46	13.00	41.80	34.96	88.60	65.10	11.73	14.40	1289.3	1007.3
Weed-free for 1 WAE*	78.13	56.56	2.50	2.16	14.06	12.36	36.90	34.13	88.70	80.83	13.76	13.90	1596.7	1138.7
Weed-free for 2 WAE	76.33	55.86	2.53	2.30	15.63	11.70	48.80	33.23	158.47	77.30	13.96	15.36	1704.0	1526.7
Weed-free for 3 WAE	71.70	56.33	2.46	2.40	15.46	11.90	63.33	35.13	198.10	110.33	14.40	12.76	2219.7	1857.7
Weed-free for 4 WAE	72.27	53.26	2.56	2.36	12.06	11.06	40.10	46.30	92.63	119.33	13.63	13.63	2332.3	2040.3
Weed-free for 5 WAE	67.83	52.50	2.83	2.63	13.80	13.83	53.57	36.73	153.63	118.37	13.40	13.10	2401.3	2102.7
Weed-free for 6 WAE	65.93	52.16	2.83	2.40	14.10	12.83	44.10	42.80	137.90	129.07	12.63	14.40	2518.3	2268.0
Weed-free for 7 WAE	66.37	51.30	2.90	2.63	16.13	14.13	59.40	40.60	171.67	121.67	12.50	14.36	2758.0	2479.3
Weed-free for 8 WAE	61.93	51.86	3.23	2.96	13.73	13.03	56.90	39.03	178.47	129.67	14.53	14.20	3111.7	2634.7
Weed-free for 9 WAE	59.50	47.06	3.40	3.06	15.90	12.10	62.20	43.20	237.97	135.30	15.93	14.46	3618.7	3167.3
Weed-free for 10 WAE	58.33	49.43	3.10	3.23	14.73	14.13	64.40	51.10	176.50	146.80	14.83	13.73	4094.0	3353.3
Weed-free for 11 WAE	57.37	41.40	3.70	3.40	15.16	11.93	70.20	54.76	234.00	153.90	14.46	14.33	4424.7	3524.7
Weed-free control	52.60	49.23	3.73	3.60	14.60	13.70	79.80	50.10	284.93	156.17	14.06	13.83	4778.3	3980.0
LSD 0.05	21.01	9.86	1.42	1.24	4.16	2.61	31.53	17.79	102.79	35.75	2.51	1.37	67.19	43.5

*Week after emergence

Table 3: Correlation coefficient of seed yield with its components

	PH	BN	NN	PN	SN	SW
Branch number/plant	-0.041					
Nod number/plant	0.178	0.244*				
Pod number/plant	-0.168	0.401**	0.435**			
Seed number/plant	-0.178	0.410**	0.438**	0.876**		
Seed weight (g^{-1})	-0.029	0.311**	0.071	0.117	0.118	
Seed yield (kg ha^{-1})	-0.330**	0.523**	0.251*	0.659**	0.762**	0.202

* and ** significant at the 0.05 and 0.01 probability level, respectively

PH = Plant Height, BN = Branch Number/plant, PN = Pod Number/plant, SN = Seed Number plant, SW = 100 Seed Weight (g^{-1}), SY = Seed Yield (kg ha^{-1}), NN= Nod number-plant

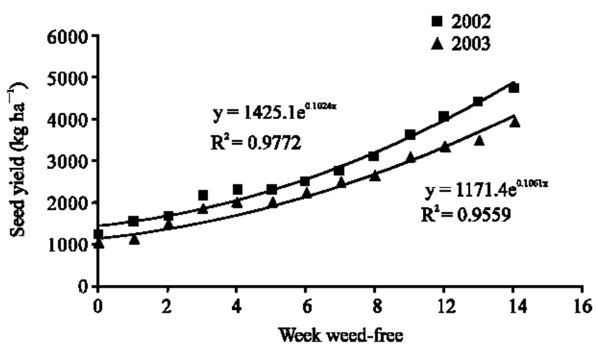

Fig. 1: Response of seed yield to duration of weed-free period

Both pod and seed numbers/plant are important yield components[14,15]. Pod number/plant increased with the increased duration of weed-free period in 2002 and 2003. The highest pod number/plant was obtained from weed-free control plot and 11 WAE in 2002 and 2003, respectively and the lowest pod number/plant was obtained from 1 WAE and 2 WAE in 2002 and 2003, respectively. Yield reductions of soybean from weed competition have been shown to be related to a decrease in the number of pods/pant[6,16,17]. Pod number plant significantly correlated with node number/plant, seed number/plant and seed yield.

When seed number/plant was considered, seed number plant values varied between 65.10 and 284.93 seed $plant^{-1}$. The highest and the lowest values were obtained from weed-free control and weedy control treatments in either year of the study. Like pod number/plant, seed number/plant increased with the increasing duration of weed-free period in both years.

Seed number/plant significantly correlated with branch number/plant, node number/plant, pod number/plant and seed yield (Table 2).

Seed weight (g 100 seed) varied between 11.73 and 15.93 g. The highest seed weight values were obtained when the crop was kept web-free for 9 WAE in 2002 and 2 WAE in 2003. Seed weight decreased with the decreased duration of weed-free period in either year (Table 2).

Duration of weed-free period significantly affected seed yield of double-cropped soybean. Seed yield values varied between 1289.3 and 4778.3 kg ha^{-1} in 2002 and between 1007.3 and 3980.0 kg ha^{-1} in 2003. The lowest and the highest seed yields were obtained from weedy control and weed-free control plots (Table 2). Seed yield exponentially increased with the increasing duration of weed-free period (Fig. 1). The result of current study showed that double-cropped soybean must be kept weed-free from emergence till to physiological maturity to obtain satisfied seed yield. The results of previous studies were differed due to the differences in weed population, weed species, cultivar used and different environmental conditions[5,6,18,19]. For example, with common ragweed (*Ambrosia artemisiifolia* L.) only 2 week weed-free period after emergence is required for optimum yield while 4 weeks of weed-free period is needed to have optimum seed yield from the fields infested with Pennsylvania smart weed (*Polygonum pensylvanicum* L.)[5,18]. Seed yield negatively correlated with plant height (-0.330**) and positively with branch number, node number, pod number and seed number plant (Table 3). The negative associations between seed yield and plant height was resulted from carbohydrate partitioning among vegetative and reproductive parts of the crop. Since the crop was allocated most of its carbohydrates to the vegetative parts to an advantage to have light.

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