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ESTIMATION OF THE CRITICAL PERIOD FOR WEED CONTROL IN SOYBEAN (*Glycine max* L) AS INFLUENCED BY PLANT DENSITY

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ABSTRACT

Two field experiments were carried out at in clay soil in Agricultural Research and Experimental Center of Agriculture at Faculty of Moshtohor, Benha University, Kalubia Governorate during 2009 & 2010 summer seasons to determine the critical period of weed competition between weeds and soybean crop through use of regression and economic approaches and also determine the relationship between weeds and soybean yield under three plant densities (105, 140 and 175 thousand plant/ fad.) and ten treatments in two types of treatments (in the first type soybean was hand weeded for different periods 3, 6, 9 and 12 weeks after sowing (W.A.S.) and for whole season ,then no further weeding was done while, in the second type weeds were allowed to grow for different periods at 3, 6, 9 (W.A.S.) until harvest the weeds were removed by hand- weeded and weed competition treatment for whole season on seed yield of soybean and associated weeds.

The main results showed that, maximum yield losses of soybean due to weed competition in the whole season were 37.6 and 34.4 % from weed free treatments in 2009 and 2010 seasons. Mathematical model for the relationship between weed free and weed competition periods according to the recommended losing yield value (10), clear that critical period of weed competition under 105 thousand plants density/fad., were (6.5 and 7.0) weeks for weed free as well as (4.25 and 4.25) for weed competition in 2009 and 2010 seasons, respectively. Under 140 thousand plant density the respective values were (6.2 and 6.3) weeks for weed free as well as (3.9 and 4.2) for weed competition and for 175 thousand plant density were (5.9 and 5.6) weeks for weed free as well as (3.5 and4.15) weeks for weed competition in 2009 and 2010 seasons, respectively . The critical period of weed treatments over plant densities were (6.45 and 6.4) weeks for weed free as well as (4.9 and 4.65) weeks for weed competition in 2009 and 2010 seasons, respectively. All weed competition exerted significant efficiency in controlling annual weeds. Weed free for the whole season treatment gave the best control for annual weeds gave the highest values of yield and yield components in two seasons. The sowing 175000 plant/fad. gave the lowest weight for dry weight for annual weeds and the tallest plants in first and second seasons. 105000 plant/fad., gave the best values of No. of branches and seed weight/plant in the first and second seasons. 140000 plant/fad., gave the highest value of No. of seed pod, weight of 100 seed and yield ton/fad. in the two seasons. Plots weeded at 3 and 6 week after sowing showed the best performance in all aspects of soybean. Such knowledge should be disseminated to farmers to keep soybean yield losses of weed competition to maintain maximum soybean seed yield. This study showed that negative correlation for annual weed weight and all studied characters under study.

Keywords: Weed infestation – Plant density – Hoeing –Critical period.

INTRODUCTION

Soybean (*Glycine max* L.) is the most important oil seeds and grain legume crop in the world, so special attention should be directed towards the proper choice of management practices to increase both seed yield and oil production. Successful weed control is one of the most important practices for economical soybean production. Losses due to weeds have been one of the major limiting factors in soybean production, where, weeds compete with soybean for light, moisture and nutrients with early- season competition, being the most critical. Knowledge about the critical period of competition and the magnitude of yield losses due to competition is the key for integrated weed management in soybean to determine the periods in which should handing of the use of pre-emergence or post emergence herbicides should be applied in this period to avoid yield losses in soybean . The time of weed removal from soybean was . as important as the extent of removal. Interference up 4 weeks after soybean emergence did not reduce soybean yield as long as moisture was adequate (Jackson *et al.*, (1985). The critical period has been defined as the period during which weeds much controlled to prevent yield losses. It has been used to determine the period when control operation should be carried out to minimize yield losses for many crops (Zimdahl 1988). Odeleye *et al.*, (2007) found that, plots left unweeded inevitably had the highest yield reduction in both varieties. On the other hand, plots weeded at 2 and 6 week after sowing showed the best performance in all aspects for both varieties of soybean. The effect of weed free treatments were significant on yield and pod number per plant while seed number in pod and 100-seed weights of soybean were not significantly affected by Moghadam *et al.*, (2010). The growth, yield parameters and yield of soybean increased when the plots were maintained weed free conditions up to 30 and 40 days after sowing. Maintaining weed free conditions beyond 40 days after sowing did not prove beneficial in case of soybean. Similarly, weed infestation before 30 day after sowing has no significant adverse effect on soybean crop. The results clearly indicate that critical period of crop weed competition in soybean lies between 30-40 days after sowing (Nagaraju and Kumar 2009 and Chirila and Chirila 2008). It has been demonstrated that usually this crop is more sensitive to the weediness between the periods of 20-35 after emergence days. If the weeds emerge earlier to the crop, weed harmfulness competition start earlier. Soybean yield was significantly affected by its densities and the yield increased as density increased up to 40 plants/m^2 (Raei *et al.*, 2008). Weed control should be carried out between 26-63 day after soybean planting to provide maximum grain yield (Keramati *et al.*, 2008). Weeds are one of the major determents in sustaining soybean productivity. The first 15-45 days of crop growth is very critical for weed competition (Yaduraju and Mishra 2004). Thus, the purpose of this study was trying to through lights about the critical period of weed control in soybean as affected by plant density.

MATERIALS AND METHODS

Two field experiments were carried out during 2009 & 2010 summer seasons in the Agricultural Research and Experimental Center of Agriculture at Faculty of Moshtohor, Benha University, Kalubia Governorate Egypt, to determine the critical period of weed/ soybean competition as affected by plant density. These treatments were arranged in split–plot design, with four replications was used in this experiment. Each experiment included 30 treatments which were the combination of three plant densities and ten weed removal or competition periods. Plant density was arranged in the main plots according to the procedure followed by (Dawson 1970) which were:

1-105000 plants/fad.
2- 140000 plants/fad.
3- 175000 plants/fad.

Weed free and weed competition treatments were assigned in sub-plots as follows:

1- Weed free for whole season (W.F).
2- Weed free for 3 weeks after transplanting.
3- Weed free for 6 weeks after transplanting.
4- Weed free for 9 weeks after transplanting.
5- Weed free for 12 weeks after transplanting.
6- Weed infestation for whole season (W.I).
7- Weed infestation for 3 weeks after transplanting.
8- Weed infestation for 6 weeks after transplanting.
9- Weed infestation for 9 weeks after transplanting.
10- Weed infestation for 12 weeks after transplanting.

After soil preparation, the main plot area divided into four sub plots each plot was 10.5 m^2 which consisted of five rows, 3.5 m length and 0.6 m width. Herati method was used in this study. Seeds of Giza 111 cultivars were planted in 31 May and 17 June in both seasons, respectively. Experimental soil was clay and chemical analysis of the tested soil were determined according to Jackson (1958), presented in Table (1).

Table (1): Physical and chemical analysis of the experimental soil from the depth of (0-30 cm.) .

Chemical analysis		Mechanical analysis	
Organic mater %	1.81	Coarse sand	4.75
Total N %	0.19	Fine sand	20.00
Available N (ppm)	35.15	Silt	23.81
Available P (ppm)	6.90	Clay	51.43
Available K(ppm)	200.00		
Total soluble. Salts(m eq./100g soil)	0.27		
PH	7.9		

The recommended cultural practices were carried out throughout the two growing seasons expect weed control treatments.

Data recorded

A- Weed measurement

One sample weed was hand pulling from one m^2 of each sub plot was taken at harvest, separated to grassy and broad-leaf and oven dried at 70° C until a constant weight to record the total annual weeds and recorded as g/m^2

B-Seed yield and its components:

At harvest, the following parameters were determined in a sample of five random guarded plants from each sub plot:-

1- Plant height (cm).
2- Number of branches/plant.
3- Number of seeds/pod.
4- Weight of seeds/plant (g).
5- Weight of 100 seed (g).
6- Seed yield (ton/fad.) was calculated from the whole sub plot area.

C- Chemical analyses.

1- Oil content %

Oil content of soybean seeds was determined by soxhlet apparatus on a dry weight basis as described by Sorenson (1947).

2- Protein content %

Protein was determined as total nitrogen by micro-Kjeldahl method, according to A.O.A.C. (1975), then, N was multiplied by 6.25 (Tripathi *et al.*,1971) to obtain protein content in soybean seeds.

D- Estimation critical weed control period:

Data of each season were statistically analyzed according to the procedures outlined by Gomez and Gomez (1984) and the treatments means were compared by least significant differences (L.S.D.). The relative and actual yield were subjected to analysis of variance using Regression Curve Estimation Functions to analysis of Statistical producers for social sciences (SPSS 12.0 for windows), to evaluate the effect of the length of the weed – free period and increasing duration of weed interference on relative lentil yields (Evans *et al.*, 2003; Knezevic *et al.*, 2002 and Norsworthy and Oliveira, 2004). Relative yield of each treatment was calculated in percent of the corresponding weed-free yield. Three response curve models namely, linear, quadratic and logistic were fitted to study the relationships between yield/fed and duration of weed-free or weed-competition period during first and second seasons. First and second model are linear and quadratic according to Neter *et al.*, (1990). A three model logistic equation proposed by Hall *et al.*, (1992) and modified by Knezevic *et al.*, (2003), was used to describe the relation between increasing duration weed interference on relative yield to determine the onset of critical period of weed control. Also, logistic regression model is presented in Agresti (1996). The dependent or response and independent or predictor variables in this model area categorical, continuous or a mix of continuous and categorical (Tabachick and Fidell 1996) use the term polychotomous]. The independent or predictor variables in logistic regression

can take any form. That is, logistic regression makes no assumption about the distribution of the independent variables. They do not have to be normaly distributed, linearly related or of equal variance within each group.

Statistical techniques:

* Linear model is estimated using the formula:

$$Y = a + b\,x$$

Where: Y = is the seed yield/fed in ardab.

a : is the Y intercept.

b : is the linear coefficient of regression.

x : is the duration of applied weed-free or weed.

Competition period.

* Quadratic polynomial model is computed using the formula:

$$Y = a + bx + cx^2$$

Where: Y = is the seed yield/fed in ardab.

a : is the Y intercept.

b : is the linear coefficient of regression.

c : is the quadratic coefficient of regression.

X : is the duration of applied weed-free or weed-competition period.

* Logistic regression equation is computed using the formula:

$$Y = 1/(1/u + (b0*(b1^{**}t)))$$

Or $= \ln(1/y - 1/u)$ Or $Y = \ln(bo) + (\ln(b1)*t)$

Where: U = is the upper boundrn value of y. The value must be a positive no/greater than the largest dependent variable value.

b0 = is the constant (a).

b1 = is the regression coefficient.

T = is the independent variable, x.

Data were analysis statistical by Central Laboratory for design and statistical analysis Research, Agriculture Research Center, Giza, Egypt.

RESLTUS AND DISCUSSION

It should be noted that the experimental field was naturally heavily infested by mixed annual weed spices. The dominant annual broad-leaf weeds were *Xanthium brasilicum, Portulaca oleracea* L., *Amaranthus ascendens* and *Corchorus olitorius* L. and the dominant annual grasses were *Echinochloa colonum, Dinebra retroflexa, Digitaria sanguinalis* L. and *Setaria viridis*.

From the weed infestation for all season treatments in table (3), the respective infestation rates under 105, 140 and 175 thousands soybean plants/m^2 were 2.43 and 2.38 ton dry weight/fed in 2009 and 2010 seasons.

1- Effect of plant density on total annual weeds, yield and yield component and chemical characters.

These results sure enough that increasing plant density from105 to 175 thousand plant/fad. gradually decreasing weeds dry weight.

The data obtained for yield and yield components of soybean which are given in Table (2), the plant densities had significant effect on it.

In the respective both seasons, the highest values of plant length was obtained by 175000 plant/fed (102.5 and 105.1 cm); followed by 140000 plants (96.0 and 99.0 cm). Meanwhile 140000 plants/fed gave the highest values of No. of seed/pod by 2.58 and 2.7, weight of 100 seed by 18.85 and 22.0 g and seed yield by 1.43 and 1.49 ton/fad. 105000 plants gave the highest values of No. of branches, by 2.61 and 2.70 and seed weight/plant 18.08 and 21.2 of the previous characteristics.

That mean the best plant density on growth and yield of soybean was 140000 plants/fed followed by 105000 plants. Also results showed that the effect of plant density was not significant on oil percentage and protein percentage in the first and second seasons.

Table (2): Effect of plant density treatments on dry weight of mixture annual weed, yield and yield component in 2009 and 2010 seasons.

Plant density	Weed (g/m^2)	Plant length (cm)	No. of branches/ plant	Seed weight/ plant(g)	No. of seed/pod.	Weight of 100 seed (g)	Yield ton/fad.	Oil %	Protein %
2009 season									
105	155.7a	91.15c	2.61a	18.08a	2.45b	17.85b	1.28b	22.50a	38.72a
140	147.5b	95.98b	2.48b	17.43b	2.58a	18.85a	1.43a	22.80a	38.83a
175	142.1c	102.50a	2.25c	15.17c	2.40c	16.35c	1.17c	22.40a	38.76a
2010 season									
105	144.2a	92.60c	2.70a	21.20a	2.60b	20.30b	1.30b	22.70a	38.83a
140	141.0b	99.00b	2.50b	19.00b	2.70a	22.00a	1.49c	22.50a	38.80a
175	138.3c	105.10a	2.30c	17.10c	2.50c	18.70c	1.26a	22.60a	38.79a

2- Effect of weed free and weed competition periods on total annual weeds, yield and yield component and chemical characters.

From the weed infestation for all season treatments in table (3), the respective infestation rates under 105, 140 and 175 thousands soybean plants/m^2 were 2.43 and 2.38 ton dry weight/fed in the first and second seasons.

Data in Table (3) show that weed free for the whole season decreased the dry weight of total weeds by 94.2 and 94.2% as compared to weed competition for the whole season in 2009 and 2010 seasons. Weed competition for the whole season gave the highest decrease in seed yield by 37.6 and 34.4 %) under 579.3 and 565.5 g/m^2 dry weight of total annual weeds in 2009 and 2010 seasons.

Such decrease in seed yield was significantly correlated with yield component namely No. of branches/plant, plant length, seed weight/plant, No. of seed/pod and weight of 100 seed

Results in table (3) showed that the effect of weed infestation treatment was not significant on oil percentage and protein percentage in the first and second seasons.

Table (3): Effect of weed infestation treatments on dry weight of total annual weed, yield and yield component in 2009 and 2010 seasons.

Weed removal or competition periods	Weed g/m²	Plant length (cm)	No. of branches/ plant	Seed weight/ plant (g)	No. of seed/pod.	Weight of 100 seed (g)	Yield t. /fad.	Oil %	Protein %
	2009 season								
Weed free for whole season	33.74h	112.4a	2.98a	24.05a	2.82a	23.83a	1.57a	22.20a	39.00a
Weed free 12 weeks	40.97g	106.2b	2.68c	21.82b	2.70b	20.50c	1.51c	21.80a	38.80a
Weed free 9 weeks	79.15d	94.47d	2.60d	18.25e	2.57c	19.00d	1.46d	23.00a	38.80a
Weed free 6 weeks	235.9c	90.17e	2.23f	15.12f	2.46d	17.67e	1.41e	22.40a	38.85a
Weed free 3 weeks	320.1b	85.53f	1.88h	12.93g	2.20f	16.00f	1.12g	23.60a	38.62a
Weed infestation for whole season	579.3a	83.03g	1.77i	10.32i	2.10g	10.00h	0.98j	21.60a	38.77a
Weed infestation 12 weeks	52.68e	89.25e	2.02g	12.05h	2.20f	13.67g	1.03i	22.50a	38.72a
Weed infestation 9 weeks	49.98ef	95.56d	2.48e	14.98f	2.40e	16.00f	1.08h	22.00a	38.84a
Weed infestation 6 weeks	47.06ef	102.2c	2.83b	18.70d	2.60c	17.67e	1.18f	23.90a	38.68a
Weed infestation 3 weeks	45.67fg	106.6b	2.97a	20.75c	2.72b	22.50b	1.56b	22.80a	38.67a
	2010season								
Weed free for whole season	32.61g	114.4a	3.10a	27.70a	2.90ab	27.11a	1.60a	21.40	38.60a
Weed free 12 weeks	37.8i	108.2b	2.70b	24.40b	2.70c	25.11b	1.56c	22.60a	38.88a
Weed free 9 weeks	73.51d	96.8e	2.60c	21.20c	2.60d	21.44d	1.50d	22.80a	39.18a
Weed free 6 weeks	213.7c	91.7f	2.20e	17.70e	2.50e	19.44e	1.47e	23.70a	38.37a
Weed free 3 weeks	307.3b	89.4g	2.10f	14.20g	2.40f	18.33f	1.27f	23.50a	39.20a
Weed infestation for whole season	565.5a	83.5h	1.80g	11.50i	2.10g	12.56h	1.05j	23.20a	38.90a
Weed infestation 12 weeks	49.56e	92.1f	2.10f	13.60h	2.40f	15.67g	1.10i	21.60a	38.85a
Weed infestation 9 weeks	46.58f	100.5d	2.50d	15.00f	2.70c	18.33f	1.20h	21.80a	38.83a
Weed infestation 6 weeks	44.44g	104.0c	2.80b	20.40d	2.80b	21.11d	1.22g	23.10a	38.53a
Weed infestation 3 weeks	40.94h	108.4b	3.00a	24.70b	2.90a	24.22c	1.57b	22.60a	38.70a

3- Effect of interaction between weed infestation periods and plant density on mixed annual weeds, yield and yield component and chemical characters.

The interaction between weed –free for the whole season under 175000 plant/fad. gave the highest reduction of dry weight of mixed annual weeds(30.93 and 31.27g/m^2). While the lowest reduction was obtain by weed infestation all under 105000 plant/fad. (606.6 and 570.5g/m^2), respectively in the first and second seasons (Table 4).

Table (4): Effect of interaction between plant density and weed infestation treatment on dry weight of mixture annual weeds in 2009 and 2010 seasons.

Season	2009 season			2010 season		
Weed removal or competition periods	Plant density 105 thousand /fad	Plant density 140 Thousand /fad	Plant density 175 Thousand /fad	Plant density 105 Thousand /fad	Plant density 140 Thousand /fad	Plant density 175 thousand /fad
Weed free all season	36.73nop	33.54op	30.93p	34.06uv	32.49v	31.27v
Weed free 12 weeks	42.96klmno	40.88lmnop	39.08mnop	39.69rs	37.76st	35.95tu
Weed free 9 weeks	82.02i	79.46i	75.96i	75.23j	73.47jk	71.83k
Weed free 6 weeks	244.5g	234.6h	228.6h	220.6g	212.2h	208.3i
Weed free 3 weeks	335.6d	317.3e	307.3f	313.8d	306.5e	301.6f
Weed infestation all season	606.6a	575.7b	555.5c	570.5a	566.6b	559.4c
Weed infestation 12 weeks	56.35j	52.07jk	49.61jklm	51.93l	49.45lm	47.31m-o
Weed infestation 9 weeks	53.36jk	49.69jklm	46.89jklmn	48.28mn	46.47no	45.01op
Weed infestation 6 weeks	50.36jkl	46.52jklmn	44.31klmn	46.1no	44.49op	42.72pq
Weed infestation 3 weeks	48.51jklm	45.67jklm	42.83klmno	42.25p-r	40.92qr	39.65rs

The interaction between weed free for the whole season under 175000 plants/fad. gave the tallest plants (119.8 and 120.5 cm) but the shortest plants (79.9 and 80.0 cm) was obtained from weed infestation all season under 105000 plants/fed in first and second seasons, respectively. The best values of No. of branches/plant and seed weight/plant were (3.3 and 3.4), (46.95 and 53.9), (42.95 and 42.0) and (25.7 and 31.2) respective due to applied weed free for all season under 105000 plant/fad. While the lowest values of these characteristics were obtained by infestation for all season under 175000 plants/fad. (1.6 and 1.7), (17.1 and 18.2), (14.85 and 15.4) and (9.3 and 10.5).

The application weed free for the whole season under 140000 plant/fed gave the highest values of No. of seed/pods weight of 100 seed and yield ton/fed by 2.9 and 3.0), (25.5 and 29.0) and (1.77 and 1.80) while the lowest values were obtained from weed infestation for all season and 175000 plant/fad. (20 and 2.0), 8.5 and 10.0) and (0.82 and 0.92) in the first and second seasons, respectively (Tables 5).

Table (5): Effect of interaction between plant density and weed infestation treatment on yield and yield component in 2009 season.

Characters	Plant length (cm)			No. of branches/plant			Seed weight/plant		
Weed removal or competition periods	105	140	175	105	140	175	105	140	175
2009 season									
Weed free all season	106.7cd	110.8b	119.8a	3.3a	3.05bc	2.6g-i	25.7a	24.7b	21.8e
Weed free 12 weeks	100.9ef	106.1cd	111.6b	2.8ef	2.7fg	2.55h-j	23.3c	22.6d	19.7fg
Weed free 9 weeks	84.3mn	95.4gh	103.7de	2.7fg	2.65gh	2.45jk	19.5g	18.9h	16.3i
Weed free 6 weeks	81.7no	90.5jk	98.3fg	2.4k	2.25l	2.05m	16.5i	15.3k	13.6m
Weed free 3 weeks	81.1no	84.0mn	91.5ij	2.0mn	1.9no	1.75p	14.4l	12.8n	11.7o
Weed infestation all season	79.9o	81.6no	87.6kl	2.0mn	1.75p	1.6q	11.0p	10.7p	9.3r
Weed infestation 12 weeks	86.6lm	89.2j-l	91.9ij	2.2l	2.05m	1.8op	13.1n	12.9n	10.2q
Weed infestation 9 weeks	90jk	94.4hi	102.3e	2.7gh	2.5i-k	2.25l	15.8j	15.5jk	13.7m
Weed infestation 6 weeks	98.1fg	101.1ef	107.4c	3.0cd	2.9de	2.65gh	20.0f	19.6fg	16.5i
Weed infestation 3 weeks	102.2e	106.8cd	110.8b	3.1b	3.0b-d	2.8ef	21.7e	21.5e	19.1h
Characters	No. of seed/pod.			Weight of 100 seed			Yield ton/fad.		
Weed free all season	2.75cd	2.9a	2.8bc	24.5a	25.5a	21.5bc	1.51e	1.77a	1.42g
Weed free 12 weeks	2.65ef	2.8bc	2.65ef	20.5cd	21.5bc	19.5de	1.47f	1.70b	1.36i
Weed free 9 weeks	2.5hi	2.65ef	2.55gh	19.5de	20.0cd	17.5fgh	1.41h	1.65c	1.32j
Weed free 6 weeks	2.42j	2.55gh	2.4j	17.5fgh	19.5de	16.0hi	1.42h	1.60d	1.25k
Weed free 3 weeks	2.2l	2.3k	2.1m	16.5ghi	16.5ghi	15.0ij	1.05p	1.28j	1.03q
Weed infestation all season	2.1m	2.2l	2.0n	10.5m	11.0lm	8.5n	1.00r	1.05p	0.90t
Weed infestation 12 weeks	2.2l	2.3k	2.1m	12.5kl	13.5jk	15.0ij	1.03q	1.10n	0.95s
Weed infestation 9 weeks	2.4j	2.5hi	2.3k	16.5ghi	17.5fgh	14.0jk	1.09no	1.15m	1.00r
Weed infestation 6 weeks	2.6fg	2.75cd	2.45ij	18.0efg	19.0d-f	16.0hi	1.20l	1.25k	1.08o
Weed infestation 3 weeks	2.70de	2.85ab	2.60fg	22.5b	24.5a	20.5cd	1.51e	1.70b	1.46f
2010 season									
Characters	Plant length (cm)			No. of branches/plant			Seed weight/plant		
Weed removal or competition periods	105	140	175	105	140	175	105	140	175
Weed free all season	109.9ef	112.7bc	120.5a	3.4a	3.2b	2.7e-h	31.2a	27.0b	24.8d
Weed free 12 weeks	104.0h	108.5e-g	112.0cd	3.0d	2.8d-g	2.4j-l	27.2b	24.8d	21.3g
Weed free 9 weeks	85.4n	97.6j	107.4g	2.9de	2.6g-j	2.3k-m	23.9e	20.9g	18.9i
Weed free 6 weeks	82.5o	91.7l	101.0i	2.4j-l	2.2l-n	2.1no	19.8h	17.jk	15.9l
Weed free 3 weeks	81.4op	91.2l	95.7jk	2.2l-n	2.1no	1.9op	16.2l	13.8n	12.7o
Weed infestation all season	80.0p	82.0op	88.6m	2.0o	1.8pq	1.7q	12.6o	11.4p	10.5q
Weed infestation 12 weeks	90.2lm	91.9l	94.1k	2.3k-m	2.1m-o	1.8pq	14.9m	13.2no	12.7o
Weed infestation 9 weeks	92.0l	102.1hi	107.3g	2.6f-i	2.5i-k	2.3k-m	17.0k	14.7m	13.4n
Weed infestation 6 weeks	97.4j	104.0h	110.5de	3.0d	2.9de	2.6f-i	22.5f	20.9g	17.8j
Weed infestation 3 weeks	102.8hi	108.1fg	114.3b	3.2b	3.0d	2.8d-g	26.3c	25.0d	22.9f
Characters	No. of seed/pod.			Weight of 100 seed			Yield ton/fad.		
Weed free all season	2.9bcd	3.0ab	2.8ef	27.0b	29.0a	25.3c-e	1.57d	1.75a	1.48f
Weed free 12 weeks	2.8ef	2.8de	2.6gh	25.0d-f	26.3bc	24.0fg	1.54e	1.68b	1.45g
Weed free 9 weeks	2.6hi	2.7f	2.5ij	21.7ij	23.0gh	19.7k	1.49f	1.60c	1.41h
Weed free 6 weeks	2.5ij	2.6gh	2.4jk	19.3kl	21.7ij	17.3no	1.45g	1.57d	1.38i
Weed free 3 weeks	2.4k	2.5ij	2.3l	18.3l-n	19.7k	17.0o	1.25m	1.35j	1.23n
Weed infestation all season	2.1m	2.3l	2.0m	13.0q	14.7p	10.0r	1.00t	1.20o	0.95u
Weed infestation 12 weeks	2.4k	2.5ij	2.2l	15.3p	17.0o	14.7p	1.02s	1.28l	0.99t
Weed infestation 9 weeks	2.7f	2.9cd	2.5ij	18.0m-o	20.0k	17.0o	1.12q	1.32k	1.12q
Weed infestation 6 weeks	2.9cd	3.0ab	2.7fg	21.3j	23.0gh	19.0k-m	1.10r	1.41h	1.15p
Weed infestation 3 weeks	2.9abc	3.0ab	2.8de	24.3ef	25.7cd	22.7hi	1.49f	1.75a	1.46g

Determination critical period of weed control as affected by weed and plant density.

Obtaining 100 percentage seed yield for soybean crop for free season from weeds (15 weeks) is high costing. So, obtaining 90% seed yield is accepted by determining critical period of weed control (CPWC) according to the recommended allowed losing yield value (10%). To achieve this target, the relation among seed yield and each of weed –free and weed competition was studied using some type of curves namely: Linear, logistic and quadratic models. Three bases were considered to compare among the three models i.e. coefficient of determination (R^2), standard error of estimate (SE) and the significance of the model. The significant model which had highest R^2 and lowest SE was the best model fitted to the yield data.

Table (6) clear the value of coefficient of determination (R^2), standard error of estimate (SE) and calculated F value of the tested models in 2009 and 2010 seasons. Results clearly present that the highest value of coefficient of determination (R^2), was in favour of logistic model for weed-free and weed competition in 2009 season and quadratic model for weed-free and weed competition in 2010 season.

The results of coefficient of determination (R^2) being 0.96 and 0.97 for weed free and being 0.97 and 0.94 for the weed competition over all treatments of the two seasons, respectively.

Data clearly present that the critical period of weed control over all studied agricultural practices according to the recommended allowed losing yield value (10 %) being 6.45 and 6.4 weeks for weed-free and being 4.9 and 4.65 weeks for weed-competition in the first and second seasons, respectively. These results showed that, the critical of weed control didn't differ more than individual agricultural practices that were studied. These accepted models had lost values of standard error of estimated compared with models and they had significant calculated if value in the two seasons. So, these models were the best of the response models tested for describing the relation between seed yield of soybean to weed-free and weed competition, (Figs. 1).

This finding was in conformity with that obtained by (Delayed *et al.*, 2007) found that, plots left unweeded inevitably had the highest yield reduction. On the other hand, plots weeded at 2 and 6 week after sowing showed the best performance in all aspects.

Table (6): Parameters of three models that were studied on the effect of weed control treatments on soybean seed yield in 2009 and 2010 seasons.

Season	Treatments	Methods	R2	S. E.	Sig.	Prediction equation	CPWC/ week allowed losing yield (10%)
2009 season	Weed-free	Linear	0.852	0.077	0.025	Y=1.103+0.335x	6.45
		Logistic	0.964	0.038	0.003	Y=ln(0.857)+ln(0.267)x	
		Quadratic	0.957	0.05	0.043	Y=0.894+0.934x1-0.003 x2	
	Weed competition	Linear	0.806	0.11	0.385	Y=0.789+0.041x	
		Logistic	0.631	0.152	0.109	Y=ln(0.6)+ln(0.271)x	
		Quadratic	0.967	0.056	0.033	Y=1.114-0.052x1+0.005x2	4.9
2010 season	Weed-free	Linear	0.873	0.052	0.02	Y=1.258+0.025x	6.4
		Logistic	0.97	0.025	0.002	Y=ln(1.08)+ln(0.194)x	
		Quadratic	0.956	0.037	0.044	Y=1.123+0.063x1-0.002x2	
	Weed competition	Linear	0.798	0.106	0.041	Y=0.873+0.39x	
		Logistic	0.632	0.143	0.108	Y=ln(0.693)+ln(0.256)x	
		Quadratic	0.945	0.068	0.055	Y=1.166-0.045x1+0.005x2	4.65

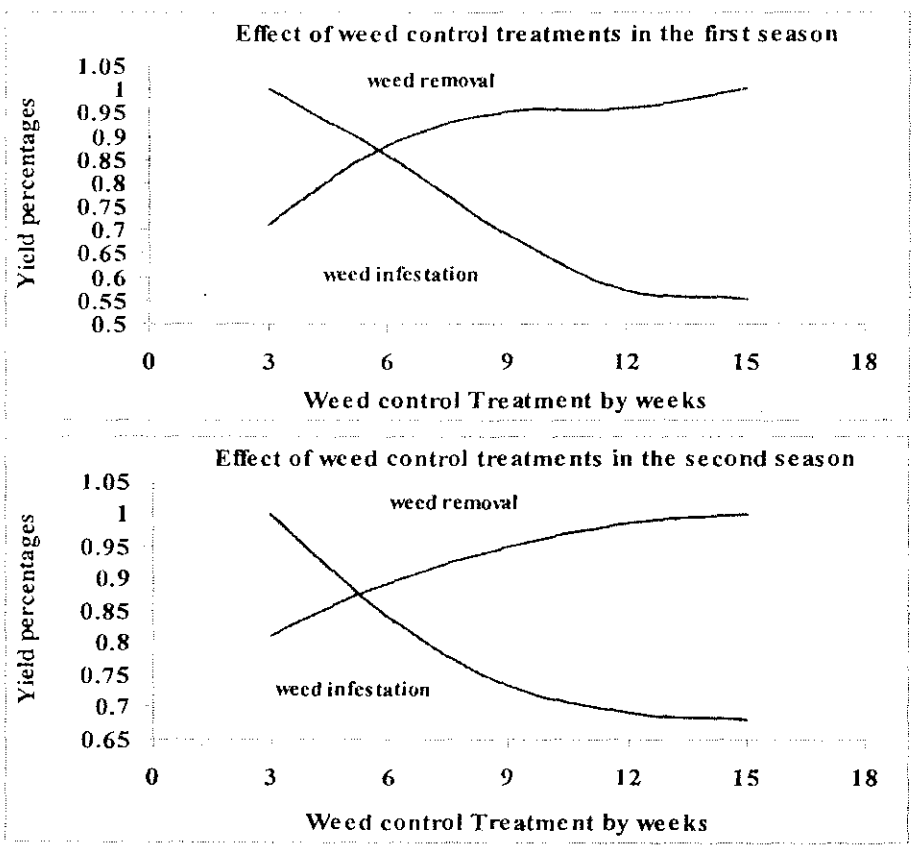

Fig (1). Effect of weed control treatments in the first season and second.

Critical period as affected by soybean plant density.

Data in table (7) clear coefficient of determination (R^2), standard error of estimate (SE) and calculated F values of three tested models to study response of soybean seed yield to weed-free and weed-competition during 2009 and 2010 seasons.

Results of 105 thousand plant/fad., density all the study clearly shows that the highest value of coefficient of determination (R^2) was in favor quadratic model for weed-free and weed-competition in two seasons, respectively. The values of (R^2) were 0.91and 0.98 for weed-free and 0.96 and 0.98 for weed-competition in two seasons, respectively.

Results of 140 thousand plant/fad., density the values (R^2) were 0.94 for logistic model of the weed-free in first season and 0.95 for quadratic model of the weed-free in the second season, meanwhile 0.97 for logistic model for weed-competition in the first season and 0.95 for quadratic model for weed-competition in the second season.

Using 175 thousand plant/fed density. the highest value of (R^2), for weed-free was of quadratic and for the weed-competition it was in favor logistic in the first seasons, respectively. These values were 0.99 and 0.97 for weed-free and weed-competition. In the second season the highest values of (R^2), for weed-free and weed competition were of quadratic by 0.97 and 0.96 for weed-free and weed competition.

According to the recommended allowed losing yield value (10 %), table (7) and Figs. (2 & 3) clear that critical period of weed control under 105 thousand plant/fad. was 6.5 and 4.25 weeks for weed-free and weed-competition, respectively. In the second season the corresponding value of critical period of weed control was 7.0 and 4.25weeks for weed-free and weed-competition. Under 140 thousand plant/fad., to accept of 90 % seed yield using accepted fitted model equations for the critical period of weed control, the values equal 6.2 and 3.9 weeks for weed-free and weed-competition in the first season, respectively. In the second season the critical period was 6.3 and4.2 weeks for weed-free and weed-competition. Using 175 thousand plant/fad., By accepted fitted model equation according to the allowed losing yield value 10 % and accepting 90 % seed yield in the same table and figs. the critical period being (5.9 and 3.5 weeks) and (5.6 and 4.15 weeks) for weed free and weed competition in the first and second seasons, respectively.

Table (7): Parameters of three models that were studied on the effect of weed control treatments and plant density on soybean seed yield in 2009 and 2010 seasons.

Season	Treatments	Density	Methods	R2	S. E.	Sig.	prediction equation	CPWC/ week allowed losing yield (10%)
2009 season	Weed-free	105	Linear	0.747	0.106	0.059	Y= 1.066 +0.333x	
			Logistic	0.899	0.067	0.014	Y=ln(0.804)+ln(0.273)x	
			Quadratic	0.914	0.076	0.086	Y= 0.786+0.113x1-0.004x2	6.5
		140	Linear	0.811	0.095	0.037	Y= 1.276+0.036 x	
			Logistic	0.939	0.054	0.006	Y= ln (1.005) +ln (0.289)x	6.2
			Quadratic	0.935	0.068	0.065	Y= 1.026+0.107x1-0.004x2	
		175	Linear	0.973	0.029	0.002	Y=0.964+0.032x	
			Logistic	0.994	0.013	0	Y= ln(0.756)+ln(0.241)x	5.9
			Quadratic	0.998	0.01	0.002	Y= 0.874+0.058x1-0.001x2	
	Weed competition	105	Linear	0.827	0.1	0.032	Y=0.809 +0.04x	
			Logistic	0.647	0.142	0.101	Y=ln (0.628) + ln(0.262)x	
			Quadratic	0.982	0.04	0.018	Y=1.114-0.0475x1 +0.005x2	4.25
		140	Linear	0.765	0.147	0.052	Y=0.815 + 0.0483x	
			Logistic	0.586	0.195	0.131	Y=ln(0.600)+ln(0.315)x	
			Quadratic	0.952	0.081	0.048	Y=1.24 -0.073x1 + 0.007x2	3.9
		175	Linear	0.831	0.088	0.031	Y=0.739 0.036x	
			Logistic	0.664	0.124	0.093	Y=ln(0.571) + ln(0.238)x	
			Quadratic	0.966	0.049	0.034	Y=0.994 - 0.0372x1 + 0.004x2	3.5
2010 season	Weed-free	105	Linear	0.838	0.059	0.029	Y= 1.241+0.024x	
			Logistic	0.959	0.029	0.004	Y=ln(1.06)+ln(0.194)x	
			Quadratic	0.96	0.036	0.04	Y=1.076+0.071x1-0.003x2	7
		140	Linear	0.902	0.055	0.013	Y=1.317+0.03x	
			Logistic	0.971	0.03	0.002	Y=ln(1.107)+ln(0.235)x	6.3
			Quadratic	0.951	0.048	0.049	Y=1.192+0.066x1-0.002x2	
		175	Linear	0.86	0.042	0.023	Y=1.22 + 0.019x	
			Logistic	0.968	0.02	0.003	Y=ln(1.08) + ln (0.15)x	6.1
			Quadratic	0.959	0.028	0.041	Y=1.104+ 0.052x -0.002x2	
	Weed competition	105	Linear	0.695	0.128	0.079	Y=0.82+0.035x	
			Logistic	0.519	0.161	0.17	Y=ln(0.669) + ln(0.228)x	
			Quadratic	0.911	0.085	0.089	Y=1.17 - 0.065x1 + 0.006x2	4.25
		140	Linear	0.826	0.103	0.033	Y=1.023+0.41x	
			Logistic	0.668	0.142	0.091	Y=ln(0.826)+ln(0.275)x	
			Quadratic	0.953	0.066	0.047	Y=1.31-0.0404x1+0.005x2	4.2
		175	Linear	0.858	0.087	0.024	Y=0.776 + 0.039x	
			Logistic	0.702	0.127	0.077	Y=ln(0.584)+ln(0.265)x	
			Quadratic	0.96	0.057	0.04	Y=1.016-0.029x +0.004x2	4.15

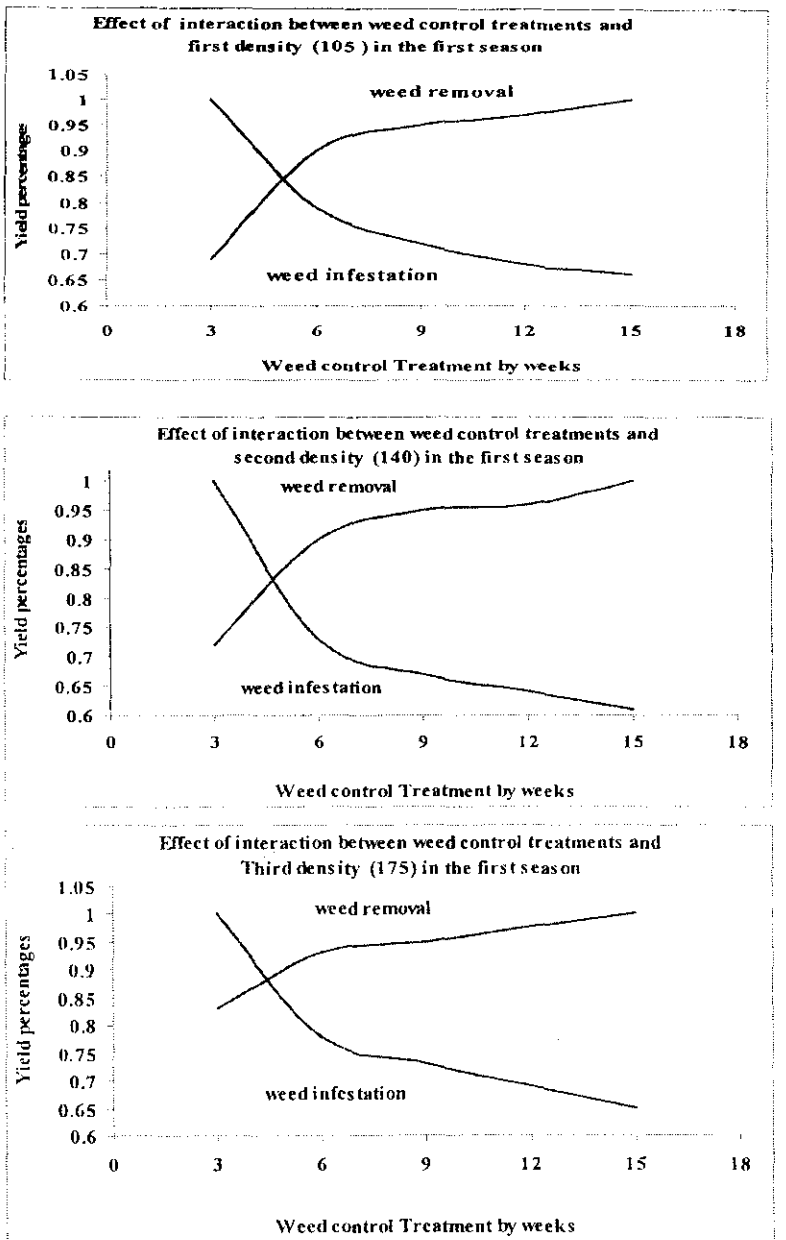

Fig (2): Effect of interaction between weed control treatments and plant density in the first season.

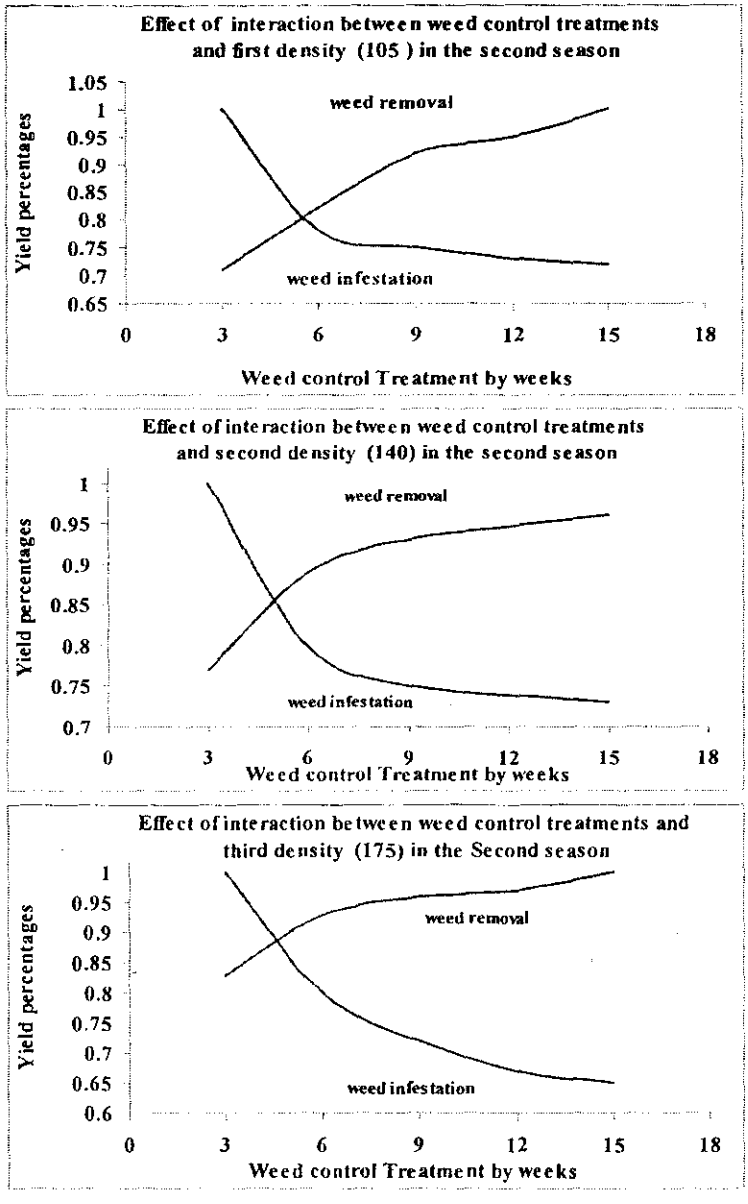

Fig (3): Effect of interaction between weed control treatments and plant density in the second season.

Economic critical period.

Data in table (8) and Fig (4 & 5) show that estimates of the threshold of critical period *using economic analysis approach* depending on the variable costs (LE) which include the costs of land preparation, sowing, fertilization,

irrigation, insect control, harvesting and rental cost of land and variable cost of hand pulling show that the early weed competition start after 3 weeks from sowing soybean when the total cost were 3150 and 3150 L.E and total income 3080 and 3492.5 LE. meanwhile late economic ended cost at 6 weeks from competition where total cost 3450 and 3450 L.E. and total income 3245 and 3355 L.E in 2009 and 201. Such approach was used by Dunan *et al.* (1995) and Mekky *et al.* (1995).

Table (8): Economic evaluation of effect of weed competition soybean in 2009 and 2010 seasons.

Weed removal or competition periods	Yield t./fad.	Income	Total costs L.E./fad.	Net benefit L.E./fad.
2009 season				
Weed free all season	1.57	4317.5	3750	567.5
Weed free 12 weeks	1.51	4152.5	3600	552.5
Weed free 9 weeks	1.46	4015.0	3450	556.0
Weed free 6 weeks	1.41	3877.5	3300	577.5
Weed free 3 weeks	1.12	3080.0	3150	-70
Weed infestation all season	0.98	2695.0	3000	-305
Weed infestation 12 weeks	1.03	2832.5	3150	-317.5
Weed infestation 9 weeks	1.08	2970.0	3300	-330
Weed infestation 6 weeks	1.18	3245.0	3450	-205
Weed infestation 3 weeks	1.56	4290.0	3600	690
2010 season				
Weed free all season	1.60	4406	3750	650
Weed free 12 weeks	1.56	4290	3600	690
Weed free 9 weeks	1.50	4125	3450	675
Weed free 6 weeks	1.47	4042.5	3300	742.5
Weed free 3 weeks	1.27	3492.5	3150	342.5
Weed infestation all season	1.05	2887.5	3000	-112.5
Weed infestation 12 weeks	1.10	3025.0	3150	-125
Weed infestation 9 weeks	1.20	3300.0	3300	-
Weed infestation 6 weeks	1.22	3355.0	3450	95
Weed infestation 3 weeks	1.57	4317.5	3600	717.5

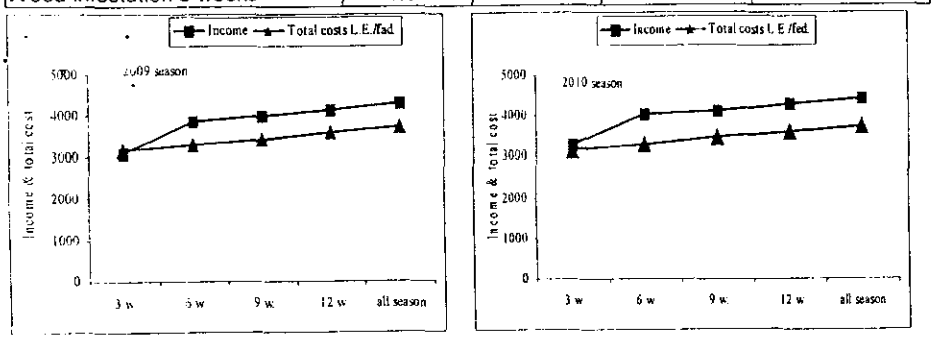

Fig. (4): The relation between income and total cost in weed free period in 2009/2010 seasons.

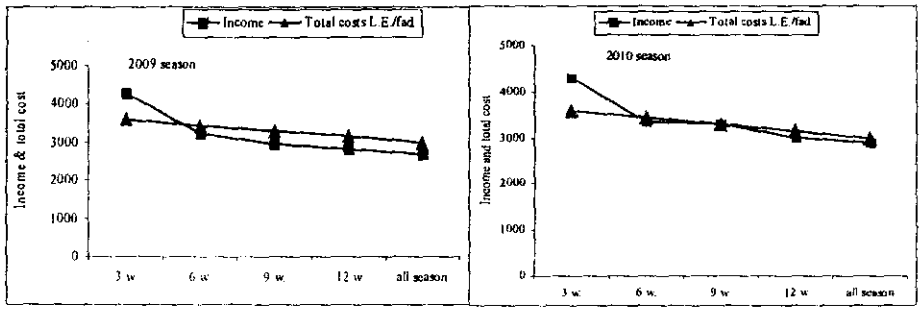

Fig (5): The relation between income and total cost in weed competition period in 2009/2010 seasons.

Correlation between all studied traits and soybean seed yield:

Data tabulated in table (9) clearly that Correlation between dry weight of total annual weeds and soybean seed yield recorded the highest value. Where it negative affected soybean seed yield by (-0.660 and -0.636) at 5 % level in the first and second seasons.

Also, correlation study reveal that the yield increase due to type of weed competition were positively contributed to the increase in the number of branches (0.965), seed weight (0.88), number of seed/pod (0.649) and weight 100 seeds (0.896).

Table (9): Correlation between all studied traits and soybean seed yield:

Characters	Total annul weed	Plant length	No. of branches/ plant	Seeds weight (g.)	No. of seed/pod	Weight 100 seeds (g.)	Yield ton/fad.
2009							
Total annual weed	-	-	-	-	-	-	-
Plant length	-0.662	-	-	-	-	-	-
No. of branches/plant	-0.714	0.636	-	-	-	-	-
Seeds weight (g.)	-0.649	0.682	0.923	-	-	-	-
No. of seed/pod	-0.665	0.562	0.916	0.945	-	-	-
Weight 100 seeds (g.)	-0.659	0.628	0.85	0.925	0.908	-	-
Yield ton/fad.	-0.660	0.621	0.965	0.88	0.849	0.896	-
2010							
Total annual weed	-	-	-	-	-	-	-
Plant length	-0.684	-	-	-	-	-	-
No. of branches/plant	-0.627	0.560	-	-	-	-	-
Seeds weight (g.)	-0.605	0.588	0.915	-	-	-	-
No. of seed/pod	-0.741	0.657	0.851	0.777	-	-	-
Weight 100 seeds (g.)	-0.655	0.663	0.84	0.906	0.851	-	-
Yield ton/fad.	-0.636	0.596	0.827	0.826	0.895	0.932	-

Conclusion

According to fit of curve estimate models it could concluded that to obtain the highest seed yield of soybean (90 %) the critical period of weed control under over three plant densities were 6 weeks for weed-free and 4 weeks for weed competition as average two years. When the plant density increase the critical period was decrease while the critical period increase when the plant density decrease. These results due to inter and intraspsefic soybean plants and soybean plants with weeds

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تقدير الفترة الحرجة لمنافسة الحشائش فى محصول فول الصويا تحت تاثير الكثافة النباتية

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٢- المعمل المركزى لبحوث الحشائش – مركز البحوث الزراعية – الجيزة. مصر.

تم إقامة تجربة حقلية خلال موسمى ٢٠٠٩ و ٢٠١٠م فى محطة البحوث والتجارب بكلية الزراعة بمشتهر جامعة بنها لدراسة الفترة الحرجة لمنافسة الحشائش على إنتاجية فول الصويا ومكوناته تحت تأثير الكثافة النباتية حيث تم تصميم التجربة فى نظام القطع المنشقة مرة واحدة فى أربعة مكررات وذلك من خلال منهج الانحدار وأيضا تقدير العلاقة بين المحصول والكثافة حيث وزعت الكثافات النباتية (١٠٥، ١٤٠، ١٧٥ ألف نبات/فدان) عشوائيا فى القطع الرئيسية بينما تم توزيع معاملات منافسة الحشائش عشوائيا فى القطع المنشقة وكانت معاملات منافسة الحشائش هى:-

١- ترك الحشائش طول الموسم.
٢- ترك الحشائش لمدة ١٢ أسبوع.
٣- ترك الحشائش لمدة ٩ أسابيع.
٤- ترك الحشائش لمدة ٦ أسابيع.
٥- ترك الحشائش مدة ٣ أسابيع.
٦- إزالة الحشائش طول الموسم.
٧- إزالة الحشائش لمدة ١٢أسبوع.
٨- إزالة الحشائش لمدة ٩ أسابيع.
٩- إزالة الحشائش لمدة ٦ أسابيع.
١٠- إزالة الحشائش لمدة ٣ أسابيع.

وقد أوضحت النتائج ما يلى:

١- أوضحت العلاقات الرياضية أن الفقد فى المحصول نتيجة منافسة الحشائش تحت الكثافات النباتية المختلفة طول الموسم وصلت الى٣٧.٦ و٣٤.٤ خلال موسمى التجربة مقارنة بمعاملة إزالة الحشائش طول الموسم.كما أوضحت أيضا أن الفترات الخالية من الحشائش وفترات منافسة الحشائش لمحصول فول الصويا من بداية الزراعة والتى يسمح بفقد ١٠% من المحصول نتيجة منافسة الحشائش تحت كثافات نباتية مختلفة (١٠٥ و١٤٠ و١٧٥ ألف نبات للفدان) أن الفترات الخالية من الحشائش تصل إلى (٦.٥ و٦.٢ و ٥.٩) (٧.٠ و٦.٣ و٦.١) أسبوعا والفترة التى تتواجد فيها الحشائش من بداية الزراعة تتراوح بين (٤.٢٥ و٣.٩ و٣.٥) (٤.٢٥ و٤.٢ و ٤.١٥) أسبوعا خلال موسمى التجربة.

٢- أثرت جميع معاملات منافسة الحشائش تأثيراً معنوياً فى مكافحة الحشائش و كانت معاملة إزالة الحشائش طول الموسم أفضل معاملة فى مكافحة الحشائش الحولية الكلية وكذلك جميع الصفات الخضرية والمحصول تحت الدراسة خلال موسمى التجربة.

٣- كانت زراعة ١٧٥ الف نبات فى الفدان أفضل معاملة فى مكافحة الحشائش الحولية وكذلك طول النبات بينما أعطت معاملة زراعة ١٠٥ الف نبات فى الفدان أحسن قيم فى عدد الفروع للنبات ووزن بذور النبات. أما زراعة ١٤٠ ألف نبات فى الفدان أعطت أكبر قيم فى عدد البذور فى القرن وزن ١٠٠ بذرة ومحصول البذور بالطن للفدان.

٤- كما أوضحت التجارب الارتباط السالب لمنافسة الحشائش الحولية الكلية مع كل الصفات تحت الدراسة.

٥- توصى الدراسة بأن تكون حقول فول الصويا خالية من الحشائش من الفترة من ٣-٦ أسابيع من الزراعة للحصول على أفضل محصول تحت كثافات زراعية مختلفة (١٠٥ و١٤٠ و١٧٥ ألف نبات للفدان).

قام بتحكيم البحث

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