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Prediction of Critical Periods for Weed Interference in Soybean

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ABSTRACT

Ten competition periods as treatments (T_{1-10}) could be valuable for predicting increase productivity (W) T_1 to T_5 were allowed to infest the crop and (WF) T_6 to T_{10} was kept weed free, weed competition periods for W and WF i.e. 3, 6, 9, 12 Weeks after emergence (WAE) and up to harvest. So, two field experiments were conducted season 2018 and 2019. Critical Periods for Weed Control (CPWC) was determined based on relative percentage yield ton/h^{-1} (SY %) of weed free as a check by fitting curves regression models (linear and non-linear, which recommended losing yield value 10%. with seed yield reduction t/h^{-1} declined from 2.3, 2.28 WF to 0.39- 0.36 W as a checked treatment for 1st, 2nd seasons, respectively about 83.33%, 85% due to relative seed yield. Gompertz as a non linear regression equation recorded 0.99* The effects of treatment classified into 3 groups where A involved 5 superior treatments (T_1, T_7, T_8, T_9 and T_{10}). However, T_4 and T_5 described inferior treatments which located in group C. Low of weed density and increasing of weed index (WI %) 80% observed for 1st season of T_4 but T_5 was translocated with increasing both weeds number and severed for weed index. It could be summarized that it should be keeping crop weed-free during stages 2nd week and continue until 8th week after crop emergence, which is providing maximum seed yield of soybean.

Keywords: Soybean, Critical periods, weed interference and linear, non linear regression

INTRODUCTION

Soybean (*Glycine max* L.) is consider one of the most evident multipurpose crop all over the world due to its richness edible oilseed, establishment as a double cropping system and use a pulse crop (Damaris *et al.,* 2019 ; Thakare *et al.*, 2006). The edible oilseed production is unself-sufficient in Egypt, which importing more than 90% of the edible oil needs from abroad. It's becoming the 1st country imported oil globally recorded by FAO (2017), therefore, effected agro-system practices must be taken to increase the productivity of oilseed under limiting increasing growing crop of margin area .Beside that strategy of raising up vertical expansion could be possible by released promising varieties and improving cultural practices especially weed control treatments.

Weed interference have possess a major limiting factors in soybean productivity which induced for seed yield reduction sharply up to77% recorded by Idapuganti *et al.,* (2005) Some have reported the yield decline as high as 84% Kachroo *et al* (2003). or even possible losses in production that can be reach in extreme cases, hinders harvest operations observed by Silva *et al.,*(2015) that depending on type of weed, soil, seasons and weed infestation intensities. This competition is important mainly in the initial stages of crop development due to weeds compete with crops by resources (water, light and nutrients) Temporal competition one of weeds competition aspects which defined by Radosevich, *et al* (2007) and it is meaning that competition over the time in which the crop is under development. However, the alternative words of competition addressed as: spatial competition caused by limited resources or not, directly or indirectly. Therefore, weed-free crops should be established to avoid these losses (Agostinetto *et al.*, 2014).

The critical period of weed control (CPWC) has been defined by Silva *et al.* (2015) as a window in the crop growth cycle during which weeds must be controlled to prevent quantitative and qualitative yield losses, and different results of CPWC showed that fluctuated degree of weed interference on crops depends on the infesting plant community (species, density and population), on the crop and environment (soil, climate and management). Thus determination CPWC is important to know the optimum timing for weed control to minimize yield losses for most crops (Zimdahl, 1988). The time of weed control in soybean was as critical as the extent of removal, interference up 4 weeks after soybean emergence did not reduce soybean seed yield (Jackson *et al*., 1985). However (Keramati *et al*., 2008) mentioned that weed control should be carried out between 26-63 day after soybean sowing to provide maximum seed yield .The period of coexistence between weeds and crops defines the level of damage caused to crop yield. Therefore, the longer this period in which the community is competing for a given resource, the losses yield maximize. Coefficients of regression equations is the most common for leading competitive indices Dew (1972) was calculated an index of competition for prediction crop losses due to weeds and describing the interaction between crop yield and weed. Kumar *et al*., (2015) were determined CPWC by calculated two different non regression models started with logistic

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equation for weedy treatments and end of critical period for weed free by using Gompertz equation with curve fitting 0.94 ,0.98 respectively . El-Gizawy *et al.*, (2012) estimated CPWC by using logistic and polynomial non linear regression curves under different three level of soybean density and results showed a significant curve fitting polynomial models in W and WF treatments but non significant in logistic model and obtain the highest seed yield of soybean (90 %) at the critical period of weed control under three plant densities were 6 weeks for weed-free (WF) and 4 weeks for weed (W) competition as average of two years.

Previous studies indicated that crop yield loss due to weed interference competition should be estimated for the decision making of the adoption of weed controlling (Gherekhloo *et al.,* 2010) and recommended for creating a greater number of studies in order to create a data base and in the future create models to predict the adequate moment of weed control for each situation.

Therefore, the present investigation planned to determine the effects of some different weed interference on soybean yield productivity. Moreover, statistical procedures such as linear, non linear regression models were proceeded to create the suitable curves fitting to prediction CPWC and minimizing the yield losses.

MATERIALS AND METHODS

1- Field Experiments

Ten periods of weed-crop competition were arranged as treatments ($T_{1\text{-}10}$) under field conditions during two summer season 2018 and 2019 at the Agricultural Experiment and Research Station, Faculty of Agriculture, Cairo University, Giza, Egypt. Representative soil samples were taken from each site at the depth of 0 to 30 cm from the soil surface before planting. The experimental soil type was clay loam in both seasons. Soil physical analysis was conducted according to Klute (1986) and chemical analysis was done according to Page *et al* (1982). Mechanical and chemical properties of the experimental soil site during the two studied seasons are shown in Table 1.

Table 1. Mechanical and chemical properties of experimental site (30 cm depth) in 2018 and 2019 seasons.

Character	Seasons	
	2018	**2019**
Mechanical analysis		
Coarse sand (%)	6	8
Fine sand (%)	34	30
Silt (%)	20	23
Clay (%)	40	39
Soil type	Clay loam	Clay loam
Chemical analysis		
Available N (kg/fed)	14.7	9.70
Available P (ppm)	1097	875
Available K (ppm)	3410	1987
Organic matter (%)	1.9	1.45
PH	7.5	7.3
EC (m/mohs/cm)	0.8	1.01

Each experiment was conducted as Randomized Complete Blocks Design (RCBD) with three replications, whereas the experimental plot consisted of 6 rows, each was 3 m long and spaced 65cm with 11.70 m^2. Giza 35 soybean cultivar used in this study and all cultural practices were applied according the recommendations of soybean production in Giza. Treatments procedures were classified into two sets according to weeks after soybean emergence (WAE). The 1^{st} set was named weedy (W) infestation by weed so that its treatments included five weedy periods for 3, 6, 9, 12 and full season or at harvested (T_1 to T_5 respectively). Another set was included the same period but due to weed free (WF) and started from T_6 to $T_{10.}$

2- Data collection

a- Yield and its components

A sample of ten random plants from each plot were collected at harvesting to determine six yield contribution characters such, plant dry weight g (PLwt), No of pods per plant (PODS), pod weight g (Pod wt), seed yield per plant (g) (SYPLA). However Weight of 100 seed (g) or seed index (SI) and Seed yield ton ha^{-1} (SYTon) were measured from plot area.

b- Weed traits

Weedy (W) treatments were collected at the time of weed removal, whereas data for weed-free (WF) treatments were taken at the time harvest. Samples in the end of soybean flowering stage, number of weed density was calculated by taking (1m×1m) three times randomly in each plot. Then, at harvest weeds were cut near from the soil surface and totally weeds observed counted m^{-2} number of weeds(No. weeds) and weed fresh weight (WFwt g) subsequently, weed index % (WI%) was computed by the formula given below

$$\textbf{Weed Index \%} = \frac{\mathbf{X - Y}}{\mathbf{X}} * \mathbf{100}$$

Where,

X = weight of seed yield (t/ha) in treatment which has highest yield and Y = weight of seed yield (t/ha) in treatment for which weed index is to be calculated.

3- Statistical analyses

Separate RCBD analysis of field data for each season was performed to explain the effects of different ten interference periods of weeds on soybean productivity according to yield and its components. Where significant of these effects was tested by variance ratio, i.e. F value at 5% level. And means of treatments were compared based on Duncan Multiple Range Test (DMRT) at $P \leq 0.05$. Analysis of variance for percentage traits such weed index (WI%) and relative of seed yield (SY %) of Weed free were carried out after arcsin transformation to normalize the data (Gomez and Gomez 1984), where the significances according to transformation and presented the actual data. On the other hand multivariate analyses such cluster analysis based on Ward's method which uses squared Euclidian distance between group averages had been used for determination closely related and linkage among different treatments effects. However, the suitable equation (s) for classified and estimated similarity effects treatments into groups through yield ton ha^{-1} and (SYTon) with density of weed was applied by linear- nonlinear regression models in order to elucidated gradients of production levels by graphically bi plot techniques. The following seven statistical models were expressed elucidating this relationship for each season and tested significances at 0.05 level of probability (p=0.05) by regression variance ratio which analyzed using analysis of variance (ANOVA). Generally in the following equation

Y: is the seed yield ton ha^{-1} (SYTon) of 2 competition sets periods dependent variables.

x : is the weed counted m^2 of weed-free or weed as independent variables .

Linear model:

$$Y = a + bx \quad \text{[Eq.1]}$$

a : is the Y intercept.
b : is the linear coefficient of regression.

Logarithmic model: [Eq.2]

Y= log bx b>0, b≠1 and x>0

b : is curve of coefficient of regression.

Quadratic polynomial:

$$Y = a + bx + cx^2 \quad \text{[Eq.3]}$$

a : is the Y intercept.
b : is the linear coefficient of regression.
c : is the quadratic coefficient of regression.

Cubic polynomial model

$$Y = a + bx + cx^2 + dx^3 \quad \text{[Eq.4]}$$

a : is the Y intercept.
b : is the linear coefficient of regression.
c : is the quadratic coefficient of regression.
D: is the cubic coefficient of regression.

Power Functions

$$Y = x^n \quad \text{[Eq.5]}$$

n: any real constant number

Exponential Function

$$Y = a^{bx}. \quad b>0 \quad \text{[Eq.6]}$$

a is constant also b :is coefficient of inverse of logarithmic curve

Yield-loss/density curves

$$Y = (a + b * x + c * x^2)^{-1} \quad \text{[Eq.7]}$$

a, b and c are constant and this type of equation constructed by two steps:

The 1st step: Weed-crop competition studies make use of a re-parameterised Michaelis-Menten model. Its initial slope of that model can be assumed as a measure of competition that is the reduction in yield (Y) when the first weed is added to the system. Therefore, the Michaelis-Methen model has been re-parameterised to include i=a/b as an explicit parameter so the re-parameterised equation is:

$$Y = \frac{iX}{1 + \frac{iX}{a}}$$

The 2nd step: This model can be also used to describe yield losses as a function of weed density. in this study produce yield data and, therefore, yield losses (in percentage) need to be calculated by using the weed-free yield and the following equation:

$$Y = \frac{Y_{WF} - Y_w}{Y_{WF}} \times 100$$

Where

Y_W is the observed yield and Y_{WF} is the weed-free yield. The yield loss to be 0 when weed density is 0. This is logical, but, it has the important consequence that the weed-free yield is constrained to be equal to the observed weed-free yield, which is not realistic. Therefore, we can reparameterise the yield-loss function, in order to use the observed yield as the dependent variable.

Indeed, from the above equation we derive:

$$Y_W = Y_{WF} - \frac{Y_L}{100} Y_{WF} = Y_{WF}\left(1 - \frac{Y_L}{100}\right)$$

Subsequently ,

$$Y_W = Y_{WF}\left(1 - \frac{iX}{100\left(1 + \frac{iX}{a}\right)}\right)$$

4- Prediction Critical Period for Weed Control (CPWC) :

Nonlinear regressions were appropriate for elucidating evaluating the critical period for weed control. Six response curve models namely linear, quadratic, cubic, exponential, Gompertz and Michaelis-Menten equation were fitted to study the relationships between relative seed yield (SY%) as dependent variables and duration of weed-free (WF) or weed-competition (W) period independent (Time) during first and second seasons. The four models (1st, 2nd, 3rd and 4th) were mentioned in the previous section (Eq 1, Eq 3, Eq 4 and Eq.6) respectively, according to Neter et al. (1990). The reason of excluded two models Eq 2 and Eq5 (logarithmic, power) respectively , those given results didn't exist values according to that assumption asymptote of the simulation model which beginning with zero times as starter durations in independent variable. However the two rest models of six according CPWC were depending on exponential and logistic theory functions Knezevic et al. (2002), as followed:

Gompertz equation:

$$Y = a * e^{-be^{-ct}} \quad \text{[Eq.5]}$$

Where

Y: is % relative yield of weed free,
a: coefficient which defines and asymptote of the model function, $a=a{\cdot}e^0$
b: coefficient that sets the displacement along the *x* axis and is a positive number
c : coefficient that sets the growth rate and is a positive number
t : is the duration of applied weed-free or weed-competition period

It used a mathematical model for a time series, where growth is slowest at the start and end of a time period. The right-hand or future value asymptote of the function is approached much more gradually by the curve than the left-hand or lower valued asymptote, in contrast to the simple logistic function in which both asymptotes are approached by the curve symmetrically.

Michaelis-Menten equation

$$Y = \frac{aX}{b+X} \quad \text{[Eq.6]}$$

This curve is convex up and Y increases as X increases, up to a plateau level. The parameter a represents the higher asymptote (for X→∞), while b is the X value giving a response equal to a/2. Indeed, it is easily proved that:

$$\frac{a}{2} = \frac{aX_{50}}{b + X_{50}}$$

which leads to

$b=X_{50}$ of time duration. The slope is first derivative to this equation could be prepared the steps of yield lose density curves

All collected data were processed subsequently by SPSS V.18 SPAW software package program.

Multivariate analysis such cluster analysis was classified contributions of seven yield components characters and weed traits to determine similarity treatments effects, respectively. Another graphical technique Dual-Scale Traits charts (DST) were assisted classification of treatments effects to predict the yield production levels.

RESULTS AND DISCUSSION

I- Weed flora distributing in the experimental site.

A total of 6 weed species were observed in experimental field during both season 2018 and 2019, which comprised of three grasses (*Gramineae* fam.) *Digitaria sangunalis*, *Echinochloa colona* and *Cynodon dactylon* were named by English naming and local name in parentheses Crabgrass (Defera) , Jungle rice (Abo-rokba) and Bermudagrs (Negil baldy) , respectively. On the other groups involved three broad leaved species *Trianthima portulacastrum* of *Aizoaceae* fam., *Xanthium strumarium*, of *Compositae* fam. and *Chochorus olitoruis* of *Tiliaceae* fam which tagged by English name and local appellation these mentioned in parentheses Desert horse-purslane (Regla afrange), Cocklebur (Shobit) and Nalta jute (Molokhia) , respectively according to Täckholm, V. (1974).

II- Effect of weed interference periods on weeds traits , yield and yield component

All studied treatments (weed free and interferences) showed that significantly effects at level of probability (p= 0.05) for yield and its components, in addition to weed traits such weeds number and weed fresh weight. (Table 2)

Obtained data showed that similarity of treatments performances of weed free treatments such as T8, T9 and T10 which tacked the same letter of LSD calculation (there were not significant), for PLwt, no. weed and WFwt around (83.5 g., 89 g) in both season respectively In addition, to other four studied traits had been the same effects in the second season for PWT, WI, SYPT/h^{-1} and SY%. Indicated that saved the efforts for weed control practices in this case while, the performance of weedy treatments such as T3, T4 and T5 were trended all studied traits except no. pods, weed fresh weight in the second season.

Table 2. Mean effects of duration of weed competition as treatments on weed studied traits, yield and its components of cultivated soybean genotype during 2018 and 2019 summer seasons.

Traits	Seasons	Treatments [1]									
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
PLwt	2018	41.50 ^{c}	35.15 ^{c}	23.20 ^{d}	20.57 ^{d}	22.19 ^{d}	68.48 ^{b}	83.82 ^{a}	85.50 ^{a}	90.61 ^{a}	88.81 ^{a}
	2019	82.66 ^{ab}	40.59 ^{c}	26.34 ^{d}	26.23 ^{d}	26.50 ^{d}	78.32 ^{b}	82.62 ^{ab}	89.78 ^{a}	88.28 ^{a}	88.91 ^{a}
No.pods	2018	63.31 ^{bc}	40.50 ^{e}	33.51 ^{ef}	26.73 ^{fg}	23.56 ^{g}	51.36 ^{d}	59.58 ^{cd}	67.83 $^{a-c}$	73.53 ^{a}	72.87 ^{ab}
	2019	47.53 $^{b-d}$	80.22 ^{b}	27.50 ^{cd}	19.85 ^{d}	18.54 ^{d}	70.73 ^{bc}	54.80 $^{b-d}$	88.50 ^{ab}	129.50 ^{a}	91.53 ^{ab}
Podwt	2018	21.20 ^{bc}	12.89 ^{f}	12.32 ^{fg}	12.09 ^{fg}	10.23 ^{g}	16.76 ^{e}	18.12 ^{de}	19.52 ^{cd}	23.80 ^{a}	23.15 ^{ab}
	2019	29.48 ^{c}	23.79 ^{d}	8.29 ^{e}	8.03 ^{e}	7.40 ^{e}	31.37 ^{bc}	34.90 ^{ab}	36.12 ^{a}	37.10 ^{a}	37.36 ^{a}
SYPLA	2018	9.49 ^{c}	6.55 ^{d}	5.65 ^{d}	5.65 ^{d}	5.52 ^{d}	10.55 ^{bc}	10.92 ^{b}	11.23 ^{b}	11.90 ^{b}	13.27 ^{a}
	2019	10.88 ^{b}	8.33 ^{c}	4.19 ^{d}	3.57 ^{d}	2.84 ^{d}	11.03 ^{b}	11.61 ^{b}	12.57 ^{b}	13.19 ^{ab}	15.45 ^{a}
SI	2018	10.97 ^{e}	10.83 ^{ef}	10.63 ^{fg}	10.57 ^{g}	10.63 ^{fg}	11.33 ^{d}	11.47 ^{cd}	11.67 ^{bc}	11.90 ^{b}	12.37 ^{a}
	2019	10.83 ^{de}	10.70 ^{e}	10.40 ^{f}	10.37 ^{f}	10.47 ^{f}	10.83 ^{de}	10.90 ^{d}	11.30 ^{c}	11.53 ^{b}	11.70 ^{a}
No. Weeds	2018	10.67 ^{c}	10.67 ^{c}	12.67 ^{c}	14.00 ^{c}	184.67 ^{a}	41.33 ^{b}	33.00 ^{b}	9.33 ^{c}	10.67 ^{c}	8.00 ^{c}
	2019	18.67 ^{b}	20.67 ^{b}	89.00 ^{a}	116.00 ^{a}	116.00 ^{a}	30.67 ^{b}	38.33 ^{b}	28.33 ^{b}	14.00 ^{b}	12.00 ^{b}
WFwt	2018	20.67 ^{c}	30.40 ^{c}	45.00 ^{c}	73.00 ^{c}	642.33 ^{a}	148.00 ^{b}	145.33 ^{b}	24.33 ^{c}	16.00 ^{c}	15.33 ^{c}
	2019	74.33 ^{c}	71.33 ^{c}	163.00 ^{ab}	190.00 ^{a}	173.18 ^{a}	91.67 ^{c}	112.33 ^{bc}	96.67 ^{c}	60.00 ^{c}	58.67 ^{c}
Weed	2018	6.33 ^{d}	46.67 ^{b}	52.67 ^{b}	80.67 ^{a}	83.33 ^{a}	50.33 ^{b}	18.00 ^{c}	8.67 ^{cd}	2.00 ^{d}	0.00 ^{d}
Index % [2]	2019	30.33 ^{cd}	48.67 ^{b}	76.33 ^{a}	80.33 ^{a}	85.00 ^{a}	42.00 ^{bc}	22.00 ^{d}	4.67 ^{e}	4.33 ^{e}	0.00 ^{e}
SY Ton h^{-1}	2018	2.16 ^{b}	1.25 ^{cd}	1.07 ^{e}	0.44 ^{f}	0.39 ^{f}	1.14 ^{e}	1.87 ^{d}	2.09 ^{c}	2.26 ^{a}	2.30 ^{a}
	2019	1.61 ^{bc}	1.15 ^{d}	0.53 ^{e}	0.45 ^{e}	0.36 ^{e}	1.33 ^{cd}	1.79 ^{b}	2.18 ^{a}	2.23 ^{a}	2.28 ^{a}
SY% of Weed	2018	93.67 ^{bc}	53.33 ^{d}	47.33 ^{d}	19.33 ^{e}	16.67 ^{e}	50.00 ^{d}	82.00 ^{c}	91.67 ^{c}	98.00 ^{ab}	100.00 ^{a}
free Check [2]	2019	69.67 ^{bc}	51.33 ^{c}	23.67 ^{d}	19.67 ^{d}	15.00 ^{d}	58.00 ^{bc}	78.00 ^{b}	95.33 ^{a}	95.67 ^{a}	100.00 ^{a}

1) Means of rows (different treatments of each season) followed by the same letters are not significantly different at 0.05 level of significant.
2) Actual data were tabulated, but transformed ones were used in statistical analysis and Duncan calculation.

Plant dry weight (g)

The plant dry weight 88.5 g in the first season and T10 in the second for all periods weed free improved plant weight and T7 to T10 didn't differ in first season and also, T8 to T10 in the second. While, weedy periods reduction plant weight and gave the lowest in T5 (weedy check) but in T1 and T2 was superior for each other's weedy periods and with significant differences in both seasons (Meschede, 2002).

1- Number and weight of pods

Weed free periods greatly increased weight of pods in all free periods in both season, except T6 weed free for 3 weeks which reduced pods weight in 2018 season. All weedy periods reduced pod weight except, T1 was the highest pod weight differ significantly with control T5. The highest number of pods $plant^{-1}$ was produced in weed free periods T9 and T10 during both seasons. The treatments weed-free, weedy up to 3 WAE and then weed free, weed free 6 WAE and then weedy gave increased in number of pods compare to other weedy treatments in both seasons. Under weedy check was observed the lowest number, these results agree with (Keramati, *et al.*, 2008).

2- Seed yield.

Weed free periods was positive effect on yield, seed yield increased with the longer weed free periods T6 to T10, (10.55 and 11.03; 10.92 and 11.61; 11.23and 12.57; 11.90 and 13.19 in both season respectively Similar results were found by Knezevic *et al.,* (2003).

The results observed in (Table 1) showed that seed yield reduced with the increasing periods of weed interference T1 to T5 in both years. The significant seed yield difference between weed free periods T6 to T10 and weedy T 5 treatment showed that weed removed must be started early during 3 WAE after and continued till to 12 weeks after emergence (WAE). Recommended period of weed removal was 9 and 12 WAE (Van Acker *et al*., 1993 and Eyherabide and Cendoya , 2002). Different studies, weed removal periods were resulted from the differences in weed species. Seed yield was significantly and positively correlated with pods/plant, pod weight, seed yield /plant and plant weight (Table 1). So, increase in one of these yield components increases in seed yield soybean. Seed yield reduction in weedy treatments was mainly resulted from the reduction in pod and seed yield/plant. Weedy periods were extended seed yield loss remarkably increased in both seasons. To reduce seed yield loss in an acceptable level, weed removed should be started at 2 WAE soybean crop emergences and continued up to 8 WAE.

3- Number and fresh weight of weed

All weed free and weedy periods were decreases number and fresh weight of weeds compared to weedy check (untreated all season) while, weed free periods in both seasons , number and fresh weight of weeds inversely proportional to the increase of weed free periods up to harvest . It has been seen that removed weeds in early stages of crop growth led to getting an economic crop to the available growth requirements perfectly. Allowing weeds to grow naturally without control will rival the economic crops of the essential growth requirements. Hence, caused reduction of the final yield to the lowest rate, especially many species of weeds considered more efficient than economic crops to get these requirements Results agreement with findings of (Smitchger *et al.,* 2012; Stagnari *et al.,* 2011).

4- Weed index

The values of weed indices (WI) observed WI in weed free periods were the minimum values, on the other hand weedy periods were the maximum values in T5 (weedy check untreated all season) first weedy period T1 and T2 were the best with significant from each other weedy periods. In the second season no significant differences between T8, T9 and T10 Similar results have also been reportedly Knezevic *et al.* (2002).

III- Multivariate analyses of effective model for yield and weed traits

1- Cluster analysis

Cluster analyses are one of the appropriate tools for grouping the tested different interferences periods according to mean effects for several traits into intra similarity and inter distinct groups mentioned by Varnica *et al.* (2018). Dendrogram of cluster analysis of separated data for each seasons of yield and weed traits are presented in Figs.1. Treatments were clustered into 2 groups (A&B) and ungroup for yield components at 5% level of significance in the first season (Fig1.A_1)

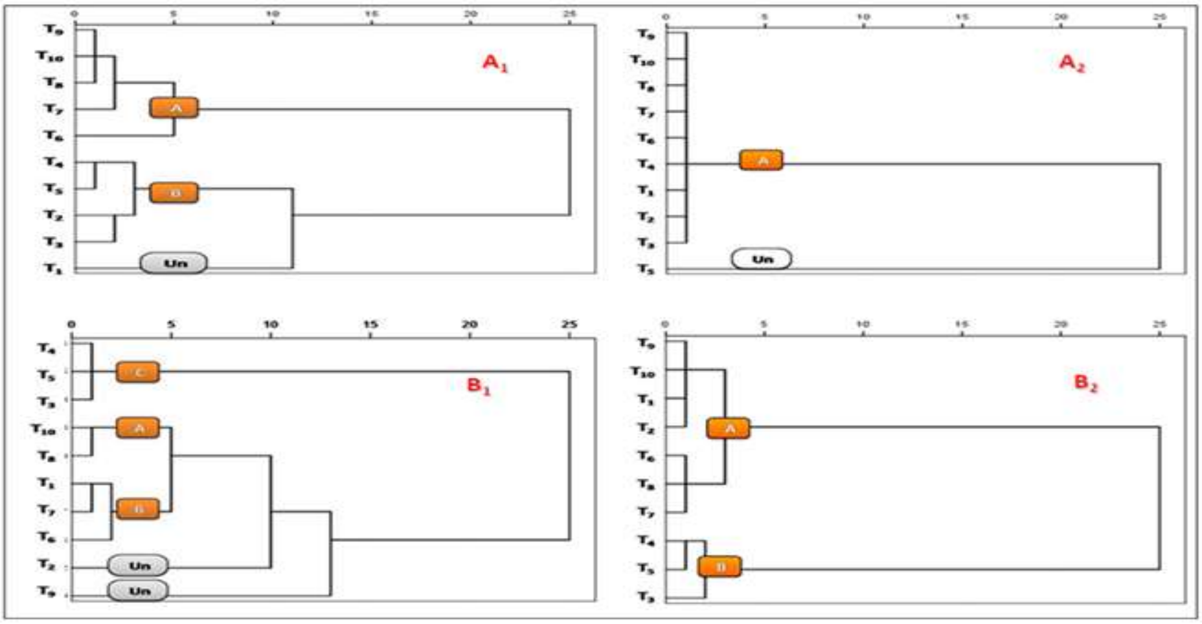

Fig1 . Dendograms using average linkage between groups according to different ten treatments for studied traits

Figures A1 & B1. dendograms clustering the 10 weed competitions and removals period (treatments) for soybean yield and its components during 2018 and 2019 seasons, respectively.

Figures A2 & B2. dendograms clustering the 10 weed competitions and removals period (treatments) for both soybean yield and weed studied traits during 2018 and 2019 seasons, respectively.

Where cluster A included five weedy free WF treatments T6, T7, T8, T9 and T10, and group B involved four weedy (W) treatments (T2, T3 T4 and T5) except T1 which classified an ungrouped to possessed moderate average in two different groups between W and WF. The second dendrogram presented in Fig.1 B_1 it was more distinguished than the Fig.1 A_1, which consisted of 3 groups first group (A) involved T10, T8, the second group (B) included T1, T7, T6 and the last group (C) it was formed by 3 treatments (T3, T4 and T5) in addition to 2 individuals treatments as ungroup T2 and T9 that summarized according grand mean of treatments in each group (Table 3),.

Table 3. Mean performance of formed four groups of 10 treatments according cluster analysis for six yield components characters in the second season 2019

Groups	PLwt	No pods	pods wt	SYPLAN	SI	SYTon
C	26.35	21.96	7.91	3.53	10.41	0.45
Un (T_2)	40.59	80.22	23.79	8.33	10.70	1.15
Un (T_9)	88.28	129.50	37.10	13.19	11.53	2.23
B	81.20	57.69	31.92	11.18	10.86	1.57
A	89.35	90.02	36.74	14.01	11.50	2.23

Croup (C) was considered inferior treatments effects of all yield components according to the severity of weed infestations. However, group A, was ranked as first position for increasing yield components characters especially Plwt was recorded 90 g. In addition to the unique ungroup T_9 was possessed the highly performed for increasing yield components although appeared its effects equivalence of almost characters of group A such SYT on with the same value 2.23 ton / hectare but, it was exceeded of no pods with 129.5 about one third folds compared the group A that may be indicated that there were significantly positive correlation between two characters according to Ghanbari *et al.*(2018). Generally , the herarical approach in the 2nd season seemed useful rather than 1st season where that other groups in spite they included different treatments and it was distinguished for sets according to the metrological data across two seasons and sustainable weed management strategies which adopted for controlling weeds and depending on soil condition and weed predominance (Swanton and Weise, 1991). On the other hands, the effects treatments on seed yield ton SYT on by weed traits presented in Fig1 A2 and B2 2018, 2019 respectively. Showed that all treatments effects compacted in one group but the T_5 isolated into ungroup in the first season and separated into two major groups A and B at the 2nd summer season. The group B was describing the huge weed density according numbers and its fresh weight that were observed folding more than other treatments of group A in field experiments table1 . The more details effects of these groups classification of weeds traits needed an alternative technique which seems to be more distinguished than cluster procedures'.

2— Dual-Scale Traits charts (DST)

The DST procedures in this investigation suggested by Isenberg *et al.* (2011) which similar to Bi-Plot or a plot as dual diminutions of two traits (no. weeds and SYTon), it was considered an alternative technique to describe the relations of effects weed numbers on soybean production (SYTon), by used several assumption in this situation such creating simulation model depends on statistical regression approaches to number of weeds (no. weeds) as a independent and seed yield production dependent variable along two sets of weed competitions W and WF treats, beside that other three bases were considered to compare among the seven models i.e. coefficient of determination (R^2), standard error of estimate (SE ±) and the significance of the model (Table 4), The significant model which had highest R^2 and lowest SE± was the best model fitted to the yield data. The main resulted in the 1st seasons showed that all suggested models were non significant except the yield density model of weed treatments (W) according coefficient of determination R^2 with 0.8. However, weed free (WF) treatments that model was non significant and observed the exponential, polynomial quadratic curves were significant with 0.78* and 0.96** respectively. On the other hands, significant of fitting curves and coefficient of determination (R^2) of models at the second season were significant for all models except two quadratic and cubic where the model fitted was power function with R^2 equaled 0.96** although the significant of density function also highly but lower than for R^2 about 0.95** and the last one was increased for SE with 2.9 than 0.62. Weed free (WF) another set of treatments as showed that non significant for all studied models except the last model also which according for density function with R^2=0.47*, but it hadn't been a strongly coefficient determination value.

Moreover, the prediction of these effects according to curve fitting scattered around grand means was provided classification of level of production (Fig2). That data had been presented by graphical according plot as dual diminutions for the previous 2 studied traits (SYTon & no. weeds), which was classified into three categories based on the seed yield (SYTon) with descending arrangement from 3 to 0 ton h^{-1}. The first class more than two tones up to the top (3 ton /h^{-1}) an named potentiality production level, the soy bean production from 2 to one ton called as attainable yield(moderated class) and the lowest productivity was didn't exceed about 1 ton evaluated as actual all observed categories tested under total numbers of weed in the horizontal scale ranged begnnist as 0 its mean asymptotic to 200 weed m^2 actually the counted weeds above 100 belonged to severed otherwise less than that indicator was located in lighter Chiarappa, 1971; Rabbinge *et al.*, 1989; Rabbinge, 1993 they explained the concept of yield levels (potential, attainable, actual) and the factors which determine them supported by a framework which largely used to address the performances of agrosystems from the biophysical and socio-economical points of view (van Ittersum and Rabbinge, 1997). That pointed out that majority of treatment effects in the first season were located in the group A (potentiated) such T1,, T8 , T9 and T10 with lighter weeds density and highst productivity the logic interpretations of this results for weak competitions , but the other group (B) included treatment i.e T_2 , T_3 , T_7 and T_6 they processed a moderate level production (attainable) although there were located into lower weeds density zone , that reason seems to be type of application treatment for removed the weeds in field practices also its fresh weight were affected.

Table 4. Significances of seven curve fitting models regression (linear – non linear) and its standard errors to predict the productions level based on the relationship between seed yield (SY Ton) with number of weeds – free or weed infestation periods in2018and 2019 summer seasons.

Curve Fitting Model	Weedy R²	Weedy SE±	Statistical Model Expression	Weedy Free R²	Weedy Free SE±	Statistical Model Expression
2018						
Linear	0.28 ns	0.70	y = -0.005x + 1.294	0.82 ns	0.23	y = -0.027x + 2.499
Logarithmic	0.34 ns	0.67	Y= -3.4 ln (x) +2.1	0.75ns	0.27	y = -0.53ln(x) + 3.421
Quadratic	0.81 ns	0.44	$y = 0.002x^2 - 0.433x + 6.126$	0.96**	0.132	$y = -0.002x^2 + 0.073x + 1.720$
Cubic	0.81 ns	0.44	$y = 0.000x^3 - 0.022x^2 + 0.111x + 2.938$	0.96ns	0.152	$y = -8E-05x^3 + 0.004x^2 - 0.080x + 2.646$
Power	0.46 ns	0.62	$y = 2.933x^{-0.40}$	0.70ns	0.183	$y = 4.519x^{-0.31}$
Exponential	0.46 ns	0.65	$y = 1.144e^{-0.00x}$	0.78*	0.18	$y = 2.628e^{-0.01x}$
Yield Density	0.80 **	a=2.9	$Y=(-3.14+0.367x-0.004x^2)^{-1}$	0. 01ns	a=23.6	$Y=(-4.6+1.11x-0.275x^2)^2$
2019						
Linear	0.90*	0.19	y = -0.010x + 1.570	0.44ns	0.34	y = -0.023x + 2.550
Logarithmic	0.92**	0.16	y = -0.55ln(x) + 3.042	0.46ns	0.34	y = -0.024ln(x) + 2.5
Quadratic	0.92ns	2.16	$y = 9E-05x^2 - 0.022x + 1.789$	0.47ns	0.41	$y = 0.000x^2 - 0.065x + 2.970$
Cubic	0.92ns	2.16	$y = -3E-05x^3 + 0.007x^2 - 0.473x + 8.156$	0.57ns	0.41	$y = 0.000x^3 - 0.031x^2 + 0.725x - 2.723$
Power	0.96**	0.15	$y = 10.29x^{-0.67}$	0.41ns	0.20	$y = 4.672x^{-0.28}$
Exponential	0.95**	0.16	$y = 1.741e^{-0.01x}$	0.39ns	0.24	$y = 2.628e^{-0.01x}$
Yield Density	0.95**	a=1.08	$Y=(-0.656+0.079x-)^{-1}$	0.47*	a=0.39	$Y=(0.297+0.013x-)^{-1}$

ns, * and ** indicate insignificant, significant at 5%and significant at 1 % level respectively

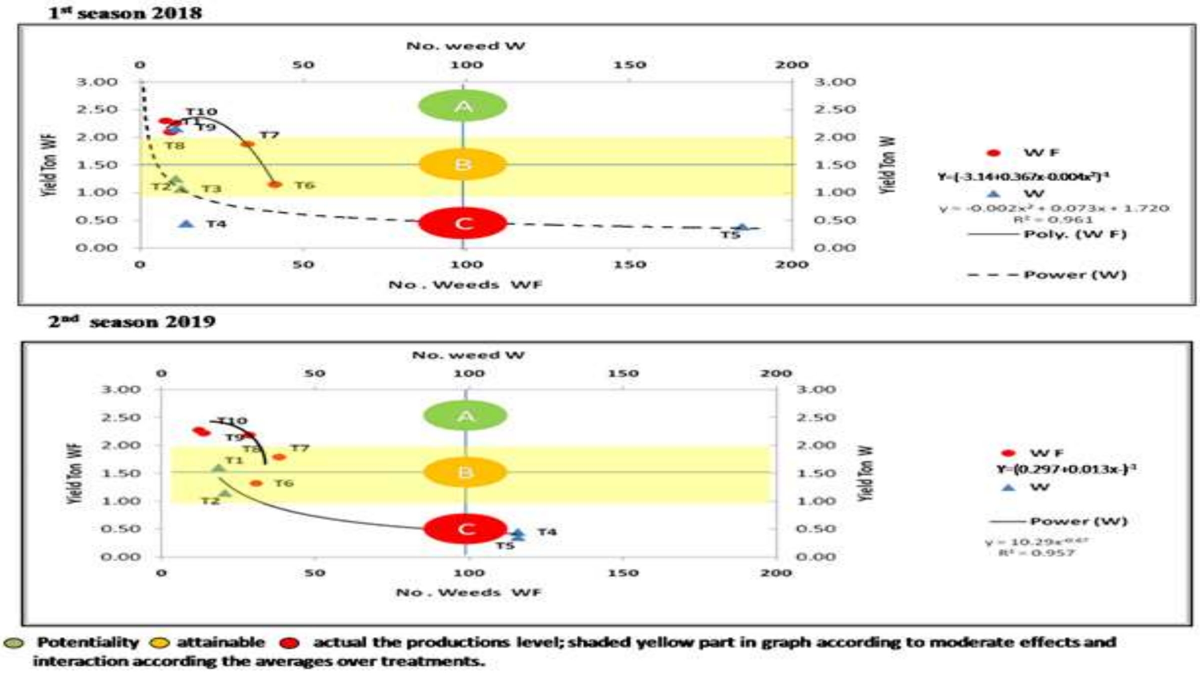

Fig.2. Illustrated groups classifications due to DST around the grand averages for soybean yield (ton h $^{-1}$) around number of weeds WF,W (free or weed infestation periods) in2018and 2019 summer seasons.

The last group C recorded the declined trends of T_5 which had a reductions of seed yield for the highly of competitions weed, it was acceptable situations for reduced and increased losses of yield, The results corroborate the findings of Vyas *et al.* (2000) and Pandya *et al*. (2005) and many others who reported enhanced soybean yield due to various weed control treatments. But the unacceptable observation was recorded of T_4 which had a unique bad performance because low of weed density and low of yield productivity that according to the type of weeds because the attributes of these treatment application it left the weed for all season therefore weedy check produced lowest yield of soybean which was significantly inferior to different weed control treatments and in this studies the annual weed were majority distributed in the experimental site , so it probably the life cycles of infested weeds shorter than growth habit of soybean crop , On the other meaning. Where the rest weeds were few numbers caused a drastic yield reduction in weedy due to heavy infestation of weeds, especially broad leaved weeds which grow faster and suppressed the crop growth. Howe and Oliver (1987) also indicated reported reduced yield in weedy check due to higher density of weeds especially broad leaved weeds.

In the second season due to the weeds interference in a dynamic way over time as crop both grows and develops the structure of treatments of groups were changed for examples group A was included the three (T_8 , T_9 and T_{10}) treatments matched to highly potentiality of production levels. However, the scenarios of expected productivity of other treatments were changed *per se* T1 reduced its production rarely to belonged for group B also the T_4 different which nearest of T_5 in the 3rd group. Generally, the competitive results of studied effects on cultivated soybean may be explained by a trade off between yield potential and competitive ability (Tilman, 1990). If a tradeoff does exist, selecting for high soybean yield under weed-free conditions would not select for weed competitiveness.

IV-Determination critical period of weed control as affected on the relative yield

Elucidating the effects of weed competition period on crop growth and how they could be incorporated into crop growth simulation models in order to model yield losses. Crop losses had been occurred because the physiology of the growing crop is negatively affected by weeds interference in a dynamic way over time as crop both grows and develops (i.e., passes through the different stages of its physiological development). As a necessary first step to achieve the modeling of yield losses we therefore need to introduce concepts that are related to yield levels and damage mechanisms because they represent the conceptual basis of modeling yield losses. Thus the critical period of weed competition was determined based on arbitrarily chosen yield loss levels (AYL) of 10%. However other studies reported 5% as the maximum AYL. But that percentage can be adjusted depending on the cost of weed control and the anticipated financial gain (Knezevic *et al*., 2003)

The relation among relative seed yield % (SY t/ha) and each of weed –free and weed competition was studied using six models Linear, quadratic, cubic, exponential, Michaelis-Menten and Gompertz models. The assumptions for detected among theses modeling based on 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 (5) illustrated that results clearly present that the highest value of coefficient of determination (R^2), was in favor of Gomperetz for weed-free both 2 season agreement with Duary and Hazra (2013) but they were determine the critical period of crop-weed competition in sesame. In addition to weedy treatments in the 1st season it were fitted the trend which disagreement with but cubic model for weed competition in 2019 season was preferred that opinioned matched of soybean for previous studies that selected quadratic with values of R2 and SE lower than selected once (cubic) . The results of coefficient of determination (R^2) being 0.99** and 0.98** for weed free and being 0.99** and 0.98** for the weed competition over all treatments of the two seasons, respectively. On the other means theses models approached to perfect fitting because nearest to 1 of coefficient of determinations, 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 2.3

and 2 weeks for weed-free and being 8.3and 8 weeks for weed-competition in the first and second season respectively, that agreement.

Data obtained in Table 2 according to similarity of effect treatments performance T8, T9 and T10 that outside of right hand of determine CPWC.

These results showed that, Maximum yield loss due to weed competition was to the tune of 83.3 and 85% in 2018 and 2019, respectively. That results acceptable with Meschede *et al.* (2002) they showed that soybean grain yield reduced in 73%, 82% and 92%, for low, medium and high weed density respectively. But El-Gizawy *et al* (2012) 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 under. That variability in their study may be causing from different seeding rates of crop and or the different selecting models

Generally, 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. 3.) This finding was in conformity with that obtained by (Delayed *et al.*, 2007) found that, plots left unweeded inevitably had the highest yield reduction. (Lindquist *et al.* (1999) point out that relative time of weed and crop emergence and densities, may explain the variation in crop-weed interference relationship among years and locations. The importance of weed emergence timing in affecting the CPWC is highlighted by Knezevic *et al.* (2002) reported that earlier weed emergence can lead to earlier beginning of critical period Therefore, sustainable weed management strategies should be adopted for controlling weeds at the proper time in right manner depending on soil condition and weed predominance to avoid environmental hazards as well as economic loss (Swanton and Weise, 1991).

Table 5. Estimation of the linear – non linear regression Fitting and its standard errors of eight models based on SY ton % as a dependant and WAE (Weeks after sowing or free or weed infestation periods) as independent for each 2019 and 2019 summer seasons.

Curve Fitting Model	Weedy R^2	Weedy SE±	Statistical Model Expression	Weedy Free R^2	Weedy Free SE±	Statistical Model Expression
2018						
Linear	0.94*	9.4	$y = -6.165x + 101.3$	0.85**	14.18	$y = 5.432x + 32.15$
Quadratic	0.95**	10.4	$y = 0.135x^2 - 8.197x + 105.4$	0.98**	3.62	$y = -0.502x^2 + 12.97x + 17.06$
Cubic	0.97*	2.16	$y = 0.047x^3 - 0.941x^2 - 2.295x + 101.5$	0.98**	3.92	$y = 0.013x^3 - 0.794x^2 + 14.57x + 16.01$
Exponential	0.93**	0.21	$y = 119.1e^{-0.13x}$	0.72*	0.40	$y = 28.55e^{0.105x}$
Gompertz	0.98**	a=1.34	$Y= 187.36\ e^{-0.59*e\ 0.08*x}$	0.99**	a=1.9	$Y= 101.36\ e^{-1.84*e- 0.33*x}$
Michaelis-Menten	0.03 ns	20.32	$Y = 101.03x/(x-6.156)$	0.94**	20.7	$Y = 133.34x/(x+4.412)$
2019						
Linear	0.91**	11.45	$y = -5.721x + 89.65$	0.82*	15.12	$y = 5.271x + 34.78$
Quadratic	0.97**	4.41	$y = 0.380x^2 - 11.43x + 101.0$	0.98**	4.37	$y = -0.536x^2 + 13.31x + 18.70$
Cubic	0.98**	5	$y = 0.063x^3 + 1.08x^2 - 3.613x + 102.3$	0.99*	3.03	$y = 0.028x^3 - 1.181x^2 + 16.85x + 16.37$
Exponential	0.96**	0.16	$y = 99.60e^{-0.13x}$	0.67**	0.45	$y = 29.26e^{0.104x}$
Gompertz	0.98**	12.75	$Y= 313e^{-5.4*e\ 0.02*x}$	0.98**	0.18	$Y= 99.97e^{-1.7*e\ 0.04*x}$
Michaelis-Menten	0.01ns	22	$Y = 21.3x/(x-2.11)$	0.95**	1.38	$Y = 124.42x/(x+3.28)$

ns, * and ** indicate insignificant, significant at 5%and significant at 1 % level respectively.

A

B

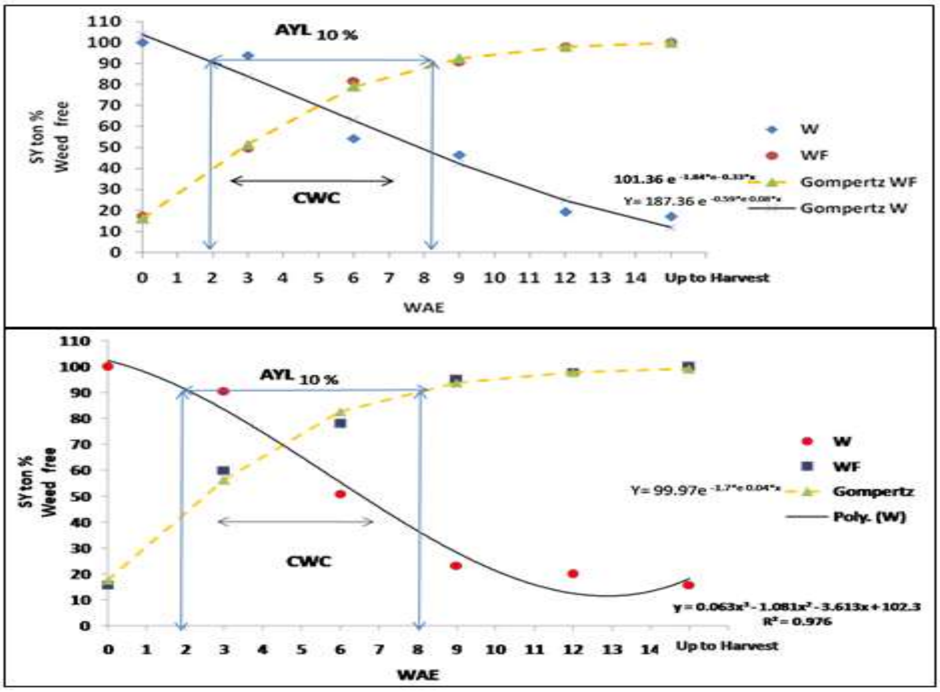

Fig. 3. Influence of period of weed infestation on relative yield of Soybean in the 2018, 2019 summer seasons A, B respectively .Symbols represent observed data; lines and dotted lines represent fitted curves;(Gompertz duration of weed interference (■); Gompertz equation for increasing weed-free period (▲)]; straigt line for cubic plonomial curve fitting deu to weedy treat and (●) the observed values of weedy treatments and caused of relative % yield ; AYL= Acceptable yield loss level (10%)

CONCLUSION

It concluded that should be keeping weed control during early growth stages of crop establishment and weed control carried out during stages 2nd week and continue until 8th week after crop emergence, that is providing maximum seed yield of soybean.

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التنبؤ بالفترات الحرجة لمنافسة الحشائش في فول الصويا

رجب عبسي ابراهيم و ابراهيم حسن يعقوب

قسم المحاصيل ـ كلية الزرعة – جامعة القاهرة

يتأثر انتاج محصول فول الصويا بشدة بمنافسة الحشائش و تحديد الفترات الحرجة لمكافحة الحشائش من العوامل الهامة في تحديد انسب فترة زمنية من عمر المحصول التي يكون مكافحة الحشائش خلالها هي الاهم, وذلك لتوفير تكاليف عمليات المكافحة، لذلك كان البحث عن انسب معادلة انحدار لتقدير تلك الفترات من الاهمية بمكان في عملية المكافحة و لزيادة انتاجية المحصول . اجريت تجربتين حقليتين في موسمي 2018 و2019 بكلية الزراعة، جامعة القاهرة، مصر، نفذت التجارب باستخدام عشرة فترات مختلفة من المنافسة (المعاملات) وزعت كل خمس معاملات في مجموعة , المجموعة الاولى (ترك الحشائش لمنافسة المحصول) ترك الحشائش لمنافسة المحصول علي فترات اسبوعية متساوية من الانبات يتم فيها ترك الحشائش و مع نهايه كل فتره منها يتم مكافحة الحشائش حتى الحصاد وهي 3 , 6 , 9 , 12 اسبوع و حتى الحصاد (كمعاملة خامسة كنترول بترك الحشائش طول الموسم دون اي مكافحة) في حين المجموعة التانية (التخلص من الحشائش) اشتملت على نفس الفترات السابقة حيث تم فيها مكافحة الحشائش و بنهاية كل فترة تتوقف المكافحة وتترك الحشائش بها حتى الحصاد . و تهدف الدراسة الي التبؤ بالفترات الحرجة لمنافسة الحشائش على انتاج فول الصويا (طن / هكتار) باستخدام معادلة انسب معادلة انحدار (خطية او غير خطية) و باستخدم التحليل العنقودي كاحد التحاليل متعددة التباين لتقسيم التأثيرات المختلفة للمعاملات تحت الدراسة علي المحصول ومكوناته وصفات الحشائش ، بالاضافة الي استخدام اسلوب بياني كعامل مساعد لتفسيرتقسيم تلك التاثيرات معتمدا في ذلك على صفتي عدد الحشائش فى متر المربع و انتاج المحصول طن / هكتار للتنبؤ بانتاج المحصول.وفيما يلي اهم النتائج: اوضحت اهم النتائج المتحصل عليها انتشار 6 انواع مختلفة من الحشائش في التجارب الحقلية للموسمين: أثرت جميع معاملات منافسة الحشائش تأثيرًا معنويًا فى مكافحة الحشائش لها و كانت معاملة إزا لة الحشائش طول الموسم أفضل معاملة فى مكافحة الحشائش الحولية الكلية وكذلك جميع صفات المحصول والمحصول تحت الدراسة خلال موسمى التجربة. قدرت الفترة الحرجة لمكافحة تلك الحشائش حيث بدات من الاسبوع الثاني حتي الاسبوع الثامن بمقدار فقد في المحصول وصل الى 83.33 و 85 % مقارنة بمعاملة الكنترول (معاملة المقارنة) في الموسمين علي التوالي باستخدام اختيار معادلة الانحدار غير الخطية (Gompertz) بمعامل تحديد معنوي 0.99 لجميع المعاملات خلال الموسمين فيما عدا الموسم الثاني لمعاملات التداخل (المنافسة) كانت معادلة التكعيبية هي الافضل .و لوحظ بالتحليل البياني ثنائي الاتجاة تقسيم تاثير المعاملات على اساس مستويات انتاج المحصول الى ثلاث مجاميع ا (متفوق), ب (متوسط) , ج (ضعيف) , حيث اشتملت المجموعة الاولى 5 معاملات متفوقة وهى المعاملة 1 و 7 و 8 و 10 , بالرغم ان المعاملة 4 و 5 وصفت على انها معاملات فقيرة الانتاج لانها واقعة في المجموعة ج .حيث المعاملة 4 سجلت دليل حشائش عالي بنسبة 80% ملحوظا باعداد قليلة من الحشائش . من خلال البانات المعروضة لوحظ كفاءة الشكل البياني ثنائي الاتجاة عن التحليل العنقودي في تفسير وتقسيم تاثيرات المعاملات المعتمد علي كثافة الحشائش والتنبؤ بمستويات انتاج المحصول حيث ضم الاخير كافة المعاملات في مجموعة او اثنين على الاكثر دون تمييز بينهم . توصى الدراسة بمقاومة الحشائش فى حقول فول الصويا مبكرا من الأسبوع الثانى حتى الأسبوع الثامن بعد الأنبات للحصول على أعلى انتاجية بوحدة المساحة.