Scientific Papers. Series A. Agronomy, Vol. LXVII, No. 1, 2024
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESULTS WITH WEEDS COMPETITION AND THEIR CONTROL IN SOYBEAN CROP

Nicolaie IONESCU, Diana Maria POPESCU

Agricultural Research and Development Station Pitesti, Pitesti-Slatina Road, km 5, 117030, Pitesti, Romania

Corresponding author email: nicolaeionescu50@gmail.com

Abstract

In the area of heavy clay soils in the South, soybeans are weedy at high levels. Currently, new, diverse and especially complex results are still required in the success of weed-free soybean crop. On the one hand, studying the relationship between soybean plants and weeds is important in determining the best measures to reduce competition. In conditions of natural weeding, large amounts of biomass are formed, on average 13.48 t/ha. In the weedy control, soybeans produce in most years between 200 and 600 kg/ha, which represents about 20% of the total. From the structure of the weeds, AM were at 61%, AD at 26%, and PD constituted 13%. The interaction with weeds resulted in total biomass losses of 2/3 of normal, and the accumulation of dry weight in grain it was reduced to a rate of only 1.1 g/m^2/day, compared to the normal 10.2 g/m^2/day. Mechanical and manual weeding brought a total production increase of 1938 kg/ha, and herbicides favored the formation of grain production of over 2000 kg/ha. In the current conditions of climate change, the reduction of herbicide doses must be done with great caution.

Key words: *competition, herbicides, weed control, weeding systems, soybeans.*

INTRODUCTION

Being a very long vegetation plant, at the same time soybeans for grains are invaded by weeds at the high levels, no matter where it is grown (Mortensen et al., 2000). The growth rate, considered slow (Hoch et al., 2006), along with the relatively wide nutrition space (50-70 cm between rows), especially during the first periods, but also during the vegetation period (Harder et al., 2007), allow to be in a big competition by a whole series of weeds (Wilson, 1998). Around the time of plant emergence there is an apparent burst of weed emergence (Riley, 2009) relative to soybean plants. Weed emergence is favored by both sunlight and soil moisture. As shown in knows, during this period the water in the soil should be sufficient (Vivian et al., 2013). Because of this, when no control measures are taken, newly emerged weeds have the appearance of a compact green carpet (Ammon, 1997). the soybean seedlings will compete from the beginning. Avoiding strong competition with weeds can be achieved through two or three moments of intervention (Jones & Medd, 2000): a) stopping the appearance of the compact and diverse vegetal carpet in the first vegetation moments of soybean (Vail & Oliver, 1993). It is known from practice that the weedy soybeans can enter into obvious competitive stress; b) the most effective control of weeds that sprout over time, staggered (Pornprom et al., 2010; Peer et al., 2013).

Summer weeds are known to emerge somewhat later and therefore effective specific herbicides are recommended (Cole et al., 1989). At the same time, works through 2-3 non-chemical interventions are recommended: mechanical and manual (Blair & Green, 1993). When choosing to use herbicides, in the case of soybeans, 2-3 treatments will be done: one mandatory for a broad spectrum of species (monocotyledonous and dicotyledonous), in pre-emergence, and 1-2 for the vegetation period of the plants (Pornprom et al., 2010). The most suitable for plants is that of 1-3 trifoliate leaves, with the presence of weeds (Ionescu et al. 1996a; Ionescu et al., 1966b). And in the case of soybeans, in order to achieve the most effective control, we resort to interspersing chemical treatments with mechanical weeding, sometimes, where possible, with manual weeding (Ionescu, 2000; Ionescu & Ionescu, 2012). The combined use of chemical and agrotechnical measures could be part of the new and beneficial rules of integrated weed management (IMB) in soybean crop (Barberi, 2003). The researches carried out lately aimed both at proving the need to reduce the degree of weeding in soybeans, and at highlighting the best and most appropriate chemical strategies (Vivian et al., 2013). The purpose of their promotion was and still is to avoid human effort, increase productivity and reduce the cost price per unit of product, plant and grain biomass (Ionescu & Ionescu, 2012). To complete the current results, new studies and experiments are needed on the ecological nature of the interrelationships between species (Vail & Oliver, 1993; Riley, 2009), the economic thresholds of damage, but also non-chemical control methods (Barberi, 2003). This paper presents the results obtained from the main competition studies, of those of ecology through sedges, as well as chemical methods of weed control. The expression of these results was and is very well supported by the concrete results obtained (Ionescu, 2000) in soybean culture in the area of heavy clay soils in the south of the country.

MATERIALS AND METHODS

The studies carried out took place over a period of several years. Within them, several series of specific research were carried out. These generally included variants of both soybean weeding and cultivation and herbicide control methods. Thus, to prove the competition between weeds and crop plants, the weed species formed by the categories: annual monocotyledons (MA), annual dicotyledons (DA) and perennial dicotyledons (DP) were quantitatively determined. Perennial monocotyledons of the type: *Agropyron*, *Cynodon*, they appeared both sporadically and in the form of irregular hearts in soybean culture. Based on the data obtained with the weeds that have accompanied soybeans year after year (Wilson, 1998), the correlation between their total biomass and losses of useful soybean production was established. Another direction of research refers to how the high degree of infestation influenced the growth and development of soybean plants. Another study carried out permanently refers to non-chemical means of control (Barberi, 2003), namely, through mechanical, manual, and their combination. Between the two directions: the chemical way and the non-chemical way, the possibilities of comparison were analyzed with the practical aim of recommending them to production and giving greater confidence to those who apply them (Blair & Green, 1993). With the combination of the present chemical and non-chemical means, a new study was recently started, to ascertain the interrelationships, the economic advantages, the time of application, but also the possibilities of reducing the doses of herbicides (Mortensen et al., 2000).

Another specific researched direction refers to the exclusive use of chemical methods - with the help of herbicides, to reduce the degree of weeding, but also to protect the soil and soybean plants (Ionescu et al., 1996a). After many years, there have been permanent improvements both from the companies, but also from the researchers into the field, so that the practice had and have at their disposal the most modern, effective and cheap options, which can be very easily adapted to the situations concrete from own clay soils (Vivian & Oliver, 1993).

In separate experiments, several classic and perspective herbicides were studied, with the aim of addressing the new issue of the European Union, reducing the doses of herbicides, regardless of the active substance, the crop plant and the European area (FAO, 2018). In the present case, in soybeans, several lower doses/ proportions were experienced for two herbicides: acetochlor and imazethapyr.

The experimental variants were placed in the station's research field, according to the Latin rectangle method, in 4 repetitions, with a surface area of 25 m^2 each. The plant samples (weeds and soybeans) were collected in the different moments of the vegetation, as well as in the maturity phase, with the metric frame, from all repetitions. The dry substance was obtained each time by oven drying, according to the common method, for 8 hours at 105°C. The statistical processing was done by the variance analysis method (Anova test), and the Excel program was used to express the average data. The varieties used were those grown in regional farms. The technology used was the one recommended by the resort.

RESULTS AND DISCUSSIONS

Considering the very low degree of competition of soybean with weeds, especially in the early moments of the vegetation (Pornprom et al., 2010), it was considered appropriate to study its infestation with local species, in the natural conditions of the clay soil eco-environment of resort. Of the multitude of species existing in a crop area, most produce obvious damage to soybeans. The interaction between these two categories: soybean plants and weeds, can be studied either separately depending on the chosen weed, or for the entire unwanted vegetal carpet. When considering means of weed control in a crop, it is preferable that the weeding be considered as a whole.

Natural weeding of the soybean crop. The number of species observed and noted was diverse and characterizes the researched crop area (Table 1). Among the species, dominant in number were annual dicotyledonous - AD, while annual monocots - AM and perennial dicots - PD were approximately equal. Some of these species were problem weeds, being highlighted in the table.

Table 1. The main important weed species from soybean crop

No.	Annual monocots	Annual dicots	Perennial dicots
1.	***Digitaria sanguinalis***	***Amaranthus retroflexus***	***Cirsium arvense****
2.	***Echinochloa crus-galli***	***Chenopodium album***	***Convolvulus arvensis***
3.	*Lolium temulentum*	***Matricaria inodora***	*Lathyrus tuberosus*
4.	*Setaria glauca*	***Polygonum persicaria***	*Rumex acetosella*
5.	*Setaria viridis*	***Hibiscus trionum***	*Sonchus arvensis*
6.		***Raphanus raphanistrum***	*Taraxacum officinale*
7.		***Polygonum hydropiper***	
8.		*Ambrozia artemisiifolia*	
9.		*Centaurea cyanus*	
10.		*Galeopsis tetrahit*	
11.		*Gypsophylla muralis*	
12.		*Polygonum aviculare*	
13.		*Sinapis arvensis*	

Cirsium arvense*- the weed-problem

From the experiments, weed species were harvested in the final phase, by category, with the metric frame. After they were all weighed together, a separation was made into three categories: MA - annual monocots, DA - annual dicots and DP - perennial dicots. The way the weeds in the untreated control evolved quantitatively was characteristic (Table 2).

How they influenced the formation of grain production according to natural weeding is shown in Figure 1. From the graph it can be seen that in most years in weeded soybeans the grain production fell between 210 and 500 kg/ha.

Table 2. Weeds evolution (t/ha biomass) by botanical groups from untreated plot

Form/years	1	2	3	4	5	Mean,%
AM	7.5	5.2	11.3	4.7	12.4	8.22/61
AD	2.3	1.1	4.3	4.2	5.8	3.54/26
PD	4.7	3.3	0.2	0.1	0.3	1.72/13
Sum	14.5	9.6	15.8	9.0	18.5	13.48/100

There were some exceptions (28% of the years) due to climate and soybean establishment technique, when naturally weeded controls produced average yields between 500 and 1000 kg/ha of soybeans.

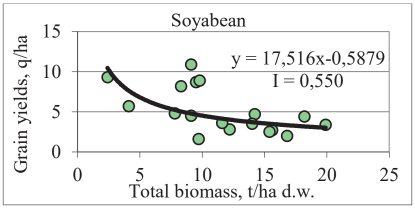

Figure 1. Correlation weeds biomass x soybean yields from the untreated plot (after Ionescu, 2012)

Competition between weeds and soybean plants. The negative impact post-sowing weeds can have on soybeans is shown in Figure 2, 1.A. The average rate of accumulation of total biomass and of soybeans, with and without weeds, showed delays by weeding. The deposition of nutrients from the grains was thus at an extremely low level. Overall, average natural soybean weeding reduced biomass accumulation to about 80% of normal. The comparative rate of accumulation of weed biomass with soybean plants with and without weeds is shown in Figure 2, 1.B. The chart highlights very well the particularly high rate of weeds in the unmaintained soybean crop. The maximum value was 50 g/m^2/day. Compared to the weed rate, weed-free soybean demonstrated the maximum biomass accumulation rate of 18 g/m^2/day. Weedy soybean showed the lowest total biomass accumulation rate, with greater variations towards the end of the growing season. The maximum value was at 5.2 m/m^2/day.

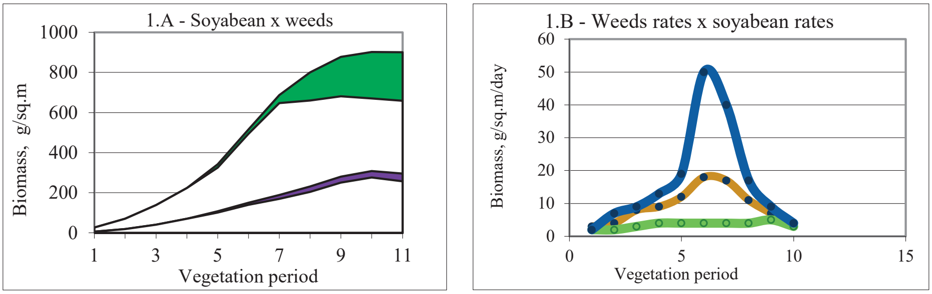

Figure 2. The evolution of biomass- total biomass and grain yield formation (1.A) and weeds biomass, soybean total biomass and grain filling rates (1.B), as affected by weeds encroachment or not (blue-weeds, brown-soybean without weeds, pale green-soybean with weeds. The x-axis represents consecutive observations with time- intervals of 10 days (after Ionescu, 2012)

From determinations at 5-day intervals regarding the submission of nutritions in grains it was found that the rate of accumulation was totally different in level and even distorting in the presence of weeds (Figure 3).

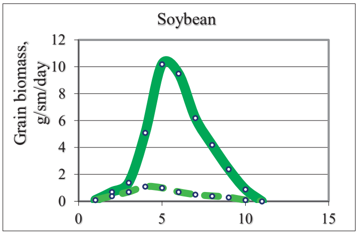

Figure 3. The grains rate of accumulation, in weed-free and weedy soybeans (after Ionescu, 2012)

Observing the data entered in the graph, it is demonstrated that for soybeans, weeding represents one of the most harmful problems of the vegetation. Indeed, under conditions of competition with weeds, soybean had a very low rate of bioaccumulation, below 5 g.m^{-2}/day from the beginning of July until harvest.

Soybean competed by weeds had maximum bioaccumulation rates of over 11.1 g.m^{-2}/day.

Table 3. Efficacy of weeding control (hoed type)

Hoeing type	Grain yields levels	
	Kg/ha	%
Mechanical + manual	1938	100.0
Mechanical	955	49.3
Manual	1125	58.0
Not hoed	512	26.4
LSD 5% =	451	23.3
LSD 1% =	597	30.8
LSD 0.1%=	807	41.6

Table 4. The efficacy of herbicides in soybean crop (after Ionescu, 2012)

No.	Herbicides	Doses/ ha	WCD, %	Weeds uncontrolled	Production increase, kg/ha
		Single applied herbicides			
1.	Acetochlor	3.0	69.3	ECHCG, AMARE	+205
2.	Alachlor	6.0	40.5	ECHCG, CIRAR	+530
3.	Pendimethalin	4.5	37.8	ECHCG	+200
4.	Dimethenamid	1.5	25.1	ECHCG, CONAR	+1135
5.	Bentazone	3.0	81.0	ECHCG	+160
6.	Bentazone forte	2.0	63.9	ECHCG, CHEAL	+240
	Mean		**50.0**		**+583**

		Combined herbicides (Tank mixed)			
1.	Alachlor + metribuzin	6+0.3	23.4	ECHCG, AMARE	+850
2.	Acetochlor + metribuzin	2+0.3	38.5	AMARE	+400
3.	Alachlor + metribuzin	8-10+0.3	18.0	ECHCG, AMARE	+670
4.	Fluazifop-butyl+bentazon	2+3	29.7	RAPRA, CONAR	+960
	Mean		**27.4**		**+611**
		Associated herbicides			
1.	Alachlor + bentazon	8.0+3.0	23.4	ECHCG	+1030
2.	Alachlor48 + bentazon	6.0+3.0	29.7	ECHCG	+728
3.	Alachlor + metribuzin + fluazifop-butyl	6.0+0.3+3.0	28.8	ECHCG, POLHY	+910
4.	Alachlor + metribuzin + bentazon	6.0+0.3+3.0	18	ECHCG	+915
	Mean		**23.3**		**+931**

*WCD - weeds covered degrees

Herbicide using in soybean crop. Newer soybean weed control tactics include three areas: weed competition with soybeans, cultivation, and herbicides. The first two directions have already been exemplified in this paper. The third direction is the use of herbicides. At the moment, there is a real arsenal of active substances such as herbicides. They are characterized by high degrees of effectiveness and selectivity, as well as appropriate strategies for each culture area. Both companies in the field and research can offer the best variants of weed control in soybean crop. And yet, under the new conditions of protection of the agricultural environment, the control of weeds in the soybean crop is used less and less exclusively with herbicides. At the same time, active substances unfriendly to the agricultural environment were removed and herbicides with no residual effect were approved. In practice, however, several decisions regarding weeding are used, taking into account the climatic conditions and the spectrum of weeds existing on the respective surfaces. Products with unilateral application are less often used. The desired effectiveness is obtained with herbicides either in combination (tank mixed) or associated (Table 4).

The problem of reducing herbicide doses is relatively new (Ionescu & Ionescu, 2012), but thanks to the new European requirements, the topic is becoming current. In the present example, the effectiveness of two treatments is shown, in different doses: 0% - without herbicide, the use of 25%, 50%, 75% and 100% of the normal doses. The evolution of the effectiveness, expressed by the GA (degree of coverage) of the control weeds, demonstrates that in soybeans, in the case of single acetochlor, the recommended (legal) dose cannot be waived, while in the case of imazethapyr the initial dose can be reduced by 25%, but only in conditions of reduced infestation, or if it is dry. If the average production of soybeans is taken into account, it can be seen that the two herbicides were significantly equal. Research of this kind is promising and will have to be carried out in as many ecological conditions as possible.

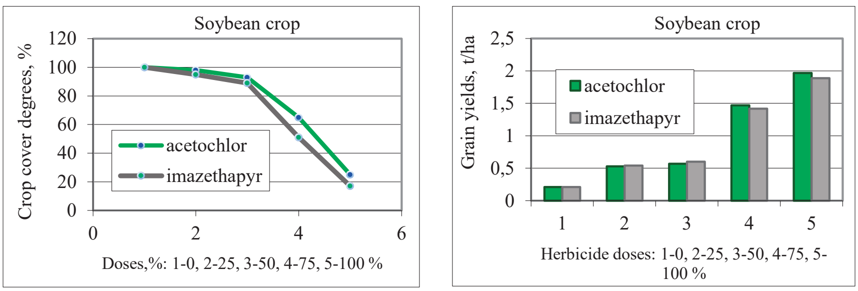

Figure 4. The influence of different doses of herbicides in reducing the weed levels from soybean crop:1 = 0% (no herbicides); 2 = 25%; 3 = 50%; 4 = 75%; and 5 = 100% herbicides of normal dose: acetochlor and imazethapyr (after Ionescu, 2012)

Table 5. Efficacy and selectivity of some herbicides applied to soybean crop

Alachlor 480 g/l+ bentazon 480 g/l+ bentazon 480 g/l (repeated)			Phytotoxicity, description EWRS scale (after Riley, 2009)		
Dozes		8+ 1,5+ 1,5 l/ha	Note	Plant tolerance	Damages %
Yields, kg/ha	No herbicides	767	1	No effect	0
	Clean check	1863	2	Dwarf, yellow plants	1
	Increase	1096	**3**	**Dwarf, yellow plants, with return**	**2**
Cover degrees	%	26	4	Chlorosis, possible return	5
Selectivity	EWRS note	**2,3**	5	Chlorosis, dwarf, thinning	10
Control level	%	82	6-9	Severe damages	25-100

Aspects of the selectivity of some herbicides applied in soybean crop. In general, herbicide treatments in soybean culture do not produce phytotoxic effects, so they are selective in their action. Not infrequently, in a soybean crop there may be times when a herbicide, especially with post-emergence application, with and without repeating this treatment, induces some phenomena whereby the soybean plants show some symptoms of damage. In other situations, through too early post-treatment, i.e. on plants that have just emerged, phenomena of growth arrest may occur. Of course, these phenomena are usually favored by climatic conditions, usually in excess. In most cases, it is found that after a short period of time these symptoms disappear, and the soybean plants resume their normal course of growth and development.

The present example shows a combined treatment between pre-emergence alachlor and post-emergence bentazone. This vegetation treatment can be repeated if the degree of weeding with dicot species requires it. This herbicide system has been used in the resort area for several years. Phytotoxicity phenomena usually did not occur. Instead, in some years these symptoms appear by repeating the post-emergence treatment. The symptoms were in the form of a slight delay in vegetation, yellowing and especially with the appearance of blistering of the leaves (Table 5). The observations show that the symptoms disappeared after a few days.

A study resulted in a weeding level of 13.48 t/ha total biomass, of which MA represented 61%, DA 26%, and DP 13%.

The levels of grain production in naturally weeded soybeans were between 200 and 500 kg/ha, which fully demonstrates the need to reduce weeding in this crop.

The competition between weeds and soybean plants demonstrated distortions both in terms of the accumulation of total biomass, then in the deposition of reserve substances in the grains, but also in their storage rhythms.

Mechanical and manual harrows have proven their effectiveness, along with improving the properties of the cultivated soil. Mechanical nets brought an average increase of 49.3%, and manual nets 58%.

The chemical control of weeds through the appropriate herbicides achieves a very good protection for about 50 days, enough for the plants to completely cover the cultivation space. Considering several herbicide strategies, the best results were obtained with associated herbicides. In some cases, either tank-mixed or single treatments can be used, according to the concrete situations of the known degrees of weeding.

The reduction of herbicide doses is increasingly desired for the protection of the agricultural environment. But this requires new experiments. From what has been achieved so far, this reduction with higher percentages should with great care.

And in soybean culture for grains, phytotoxicity phenomena can occur through some chemical treatments, due to the decrease in selectivity, but from what has been observed so far, their manifestation has been in short time.

CONCLUSIONS

Soybeans are among the field plants that get weeded at very high levels. The main causes are: the specific reserve of seeds in the soil and the very reduced competition of seedlings to compete with weeds.

For the practical activity, the results obtained in several directions are of particular importance: a) the study of the competition between soybean plants and weeds, with which the intensity of the control measures is established, b) the effectiveness of cultivation in reducing this competition, as a mild measure towards the environment of culture and c) the correct use of the recommended herbicides.

A study resulted in a weeding level of 13.48 t/ha total biomass, of which MA represented 61%, DA 26%, and DP 13%.

The levels of grain production in naturally weeded soybeans were between 200 and 500 kg/ha, which fully demonstrates the need to reduce weeding in this crop.

The competition between weeds and soybean plants demonstrated distortions both in terms of the accumulation of total biomass, then in the deposition of reserve substances in the grains, but also in their storage rhythms.

Mechanical and manual harrows have proven their effectiveness, along with improving the properties of the cultivated soil. Mechanical nets brought an average increase of 49.3%, and manual nets 58%.

The chemical control of weeds through appropriate herbicides achieves very good protection for about 50 days, enough for the plants to completely cover the cultivation space. Considering several herbicide strategies, the best results were obtained with associated herbicides. In some cases, either tank mixed or single treatments can be used, according to the concrete situations of the known degrees of weeding.

The reduction of herbicide doses is increasingly desired for the protection of the agricultural environment. But this requires new experiments. From what has been achieved so far, this higher percentage reduction should be done with great care.

And in soybean culture for grains, phytotoxicity phenomena can occur through some chemical treatments, due to the decrease in selectivity, but from what has been observed so far, their manifestation has been short-lived.

REFERENCES

Ammon, H.U. (1997). Weed control in transition- from weed eradication in vegetațion management. *Proceedings of 10th EWRS Symposium, Poznan, Poland*. 87- 94.

Barberi, P. (2003). Preventive and cultural methods for weed management. In: Labrada, R.(Ed.). *Weed management for developing countries*. FAO Plant Production and Protection Paper, 120. 179-194.

Blair, A.M., Green, M. (1993). Integrating chemical and mechanical weed control to reduce herbicide use. *Crop Protection Conference- Weeds, Brighton, UK*. 985- 990.

Cole, T.A., Wentie, G.R., Wilcut, T.W., Nichs, T.V. (1989). Behaviour imazethapyr in soybeans (*Glycine max*), peanuts (*Arachis hypogaea*) and selected weeds. *Weed Science, 37*. 639.

Food and Agriculture Organization of the United Nations. (2018). *FAOSTAT statistical database*. Hppt://www.fao.org/faostat/en/#data/QC.

Harder, D.B., Sprague, C.L., Renner, K.A. (2007). Effect of soybean row width and population on weeds, crop yield, and economic return. *Weed Technology, 21*. 744- 752.

Hoch, S.M., Knezevic, S.Z., Martin, A.R., Lindquist, J.L. (2006). Soybean row spacing and weed emergence time influence weed competitiveness and competitive indices. *Weed Science, 54*. 38- 46.

Ionescu, N., Șarpe, N., Popescu, A., Păunescu, G. (1996a). Cercetări privind gradul de îmburuienare și al principalelor măsuri de combatere a buruienilor din cultura soiei. *Simpozionul 10 SRSCB, Sinaia*. 115-123.

Ionescu N., Perianu, A., Popescu, A., Șarpe, N.,Roibu, C. (1996b). Weed control in corn and soybean crops by mechanical and manual management practices. *Proceedings 10th Colloque International sur la Biologie des Mauvaises Herbes, Dijon, France*. 359-365.

Ionescu, N. (2000). Combaterea buruienilor și protecția mediului în cultura cerealelor și a plantelor tehnice. *Editura Nelmaco Impex, București*. 59- 103.

Ionescu., N.E., Ionescu, S.G. (2012). Cercetări privind reducerea gradului de îmburuienare din cultura soiei prin metode chimice și nechimice. *Analele INCDA Fundulea, 77*. 173-184.

Jones, R.E., Medd, R.W. (2000). Economic thresholds and the case for longer term approaches to population management of weeds. *Weed Technology, 14*. 337-350.

Mortensen, D.A., Bastiaans, L., Sattin, M. (2000). The role of ecology in the development of weed management systems: an outlook. *Weed Research, 40*. 49- 62.

Peer, F.A., Hassan, B., Lone, B.A., Qayoom, S., Ahmad, L., Khanday, B.A. (2013). Effect of weed control methods on yield and yield attributes of soybean. *African Journal of Agricultural Research, 8*. 6135-6141.

Pornprom, T., Sukcharoenvipharat, W., Sansiriphun, D. (2010). Weed control with pre-emergence herbicides in vegetable soybean (*Glycine max* L. Merrill). *Crop Protection, 29*. 684–690.

Riley, D. (2009). Economic Injury (EIL) and Economic Threshold (ET). *Concepts in Pest Management. University of Georgia: Tiffon*, GA, USA.

Vivian, R., Reis, A., Kálnay, P.A., Vargas, L., Ferreira, A.C.C., Mariani, F. (2013). Weed management in soybean- issues and practices. *In Soybean- Pest and Resistance*, El-Shemy, H.A.- Ed., In Tech: Rijeka, Croatia. 47- 84.

Vail, G.D., Oliver, L.R. (1993). Barnyardgrass (*Echinochloa crus-galli*) interference in soybeans (*Glycine max*). *Weed Technology, 7*. 220–225.

Wilson, J.B. (1998). The effect of initial advantage on tye course of plant competition. *Oikos, 51*. 19-24.