GROWTH, NODULATION, AND YIELD OF SOYBEAN AND ASSOCIATED WEEDS AS AFFECTED BY WEED MANAGEMENT[1]

Crescimento, Nodulacão, e Rendimento da Soja Influenciados por diferentes Manejo de Plantas Daninhas

ABDELHAMID, M.T.[2] and EL-METWALLY, I.M.[2]

RESUMO - Dois experimentos de campo foram conduzidos na fazenda experimental do Centro de Pesquisa Nacional em Shalakan, Kalubia Governorate, Egito, durante 2006 e 2007, para estudar o efeito de três herbicidas de pré-emergência, prometryn [doses de 0.75, 1.5 e 2.25 kg ha^{-1}], oxadiargyl [doses de 240, 480 e 720 g ha^{-1}] e butralin [doses de 1.20, 2.40 e 3.36 kg ha^{-1}], dois tratamentos capinados e um controle sem capina, avaliando a infestação de plantas daninhas, a nodulação, o crescimento, o rendimento, e os componentes do rendimento em plantas de soja. Dois tratamentos resultaram em maior redução de plantas daninhas expressa em menores pesos frescos e secos das plantas dicotiledôneas, gramíneas e total. A percentagem de matérias das plantas daninhas comparada ao tratamento sem capina foi de 98.3, 92.64 e 96.9% em dicotiledôneas, gramíneas e total de plantas infestantes, respectivamente. A aplicação de três herbicidas em doses maiores ou nas doses recomendadas reduziu significantemente o peso fresco e seco das plantas daninhas comparado com o tratamento com capina. Os resultados indicaram que todos os três herbicidas nas maiores doses diminuíram o número, peso fresco e seco dos nódulos, raiz, caule e peso seco total da planta, enquanto duas capinas manuais aumentaram significativamente das características citadas. Duas capinas manuais e os herbicidas de pré-emergência aplicados nas doses recomendadas aumentaram o rendimento da soja e seus atributos. Duas capinas manuais produziram maiores números de vagens por planta, peso de vagem por planta e número de sementes por planta em 140,7; 150,0 e 59,8%, respectivamente, comparado ao tratamento capinado. Por outro lado, oxadiargyl aplicado na dose recomendada (480 g ha^{-1}) apresentou maior rendimento de semente (g $planta^{-1}$), rendimento de semente (kg ha^{-1}) e rendimento biológico (g $planta^{-1}$) que o tratamento sem capina em 87,3; 85,0 e 88,2%, respectivamente. Prometryn na dose de 1,50 kg ha^{-1}, seguido de duas capinas manuais produziu a maior percentagem de proteína na parte aérea e sementes como também de óleo na semente, comparado a outros tratamentos de controle de plantas daninhas.

Palavras-chave: *Glycine max*; herbicidas, manejo de plantas daninhas.

ABSTRACT - Two field experiments were conducted at the experimental farm of the National Research Centre at Shalakan, Kalubia Governorate, Egypt, during 2006 and 2007 seasons, to study the effect of three pre-emergence herbicides, prometryn [at the rate of 0.75, 1.5 and 2.25 kg ha^{-1}], oxadiargyl [at the rate of 240, 480 and 720 g ha^{-1}] and butralin [at the rate of 1.20, 2.40 and 3.36 kg ha^{-1}], two hand hoeing treatments and a nonweeded check, on weed infestation, nodulation, growth, yield and yield attributes of soybean plants. Two hand hoeing treatments resulted in the highest weed depression expressed as the lowest fresh and dry weights of broadleaved, grassy and total weeds. The reduction percentage in weed dry matter compared to the nonweeded treatment was 98.3, 92.64 and 96.9% in broadleaved, grassy and total weeds,

[1] Recebido para publicação em 13.3.2008 e na forma revisada em 16.6.2008.
[2] National Research Centre, Botany Department, Dokki, Cairo, Egypt.
* Corresponding author, <magdi.abdelhamid@yahoo.com>.

respectively. Application of the three herbicides at higher or recommended doses significantly reduced fresh and dry weight of the weeds compared to the nonweeded treatment. The results indicated that all the three herbicides at rates higher than the recommended markedly decreased the number, fresh and dry weight of nodules as well as root, shoot and total dry weight plant^{-1}, while application of two hand hoeing treatments significantly increased these traits. Two hand hoeing treatments and pre-emergence herbicides at the recommended rates markedly increased soybean yield and its attributes. Two hand hoeing treatments gave the highest values of number of pods per plant^{-1}, weight of pods per plant^{-1} and number of seeds per plant^{-1} by 140.7, 150.0 and 59.8%, respectively, compared to the nonweeded treatment. On the other hand, oxadiargyl at the recommended rate (480 g ha^{-1}) was the best treatment for promoting seed yield (g plant^{-1}), seed yield (kg ha^{-1}) and biological yield (g plant^{-1}) compared to the nonweeded treatment by 87.3, 85.0 and 88.2%, respectively. Prometryn at the rate of 1.50 kg ha^{-1}, followed by two hand hoeing treatments, produced the highest shoot and seed protein percentage as well as seed oil percentage, compared to the other weed control treatments.

Keywords: *Glycine max*, herbicides, weed management.

INTRODUCTION

Soybean (*Glycine max*) is one of the most important summer leguminous crops, extensively successful in many provinces in Egypt and worldwide. It consists of around 20% oil and 40% protein. Therefore, it is an excellent source of food for human and animal consumption. Reduction in soybean yield due to weed infestation varies from 20 to 77% (Tiwari & Kurchania, 1990), depending on type of weed, and soil, seasons and weed infestation intensities. Weed infestation removed 21.4 kg N and 3.4 kg P ha^{-1} in soybean (Pandya et al., 2005). Two hand hoeings are recommended for effective weed control in soybean (Jain et al., 2000; Rakesh & Shirvastava, 2002; Galal, 2003; Singh & Jolly, 2004). Ahmed et al. (2001) reported that application of two hand hoeings is more effective in suppressing weeds and increasing soybean seed yield. Today, there is a great manual labor shortage and a rise in wage scale. Thus, chemical weed control is necessary to decrease cost and to increase soybean productivity. This crop is a large herbicide consumer, and almost 100% of the planted area in Egypt is herbicide-treated. The advantages of herbicide use are high efficiency in weed control, the presence of selective products soybean at the lowest cost, compared to other available weed control methods. Despite the satisfactory weed control results, many questions remain on the effect of herbicides on the N_2 fixation process, since the soybean crop is dependent on symbiosis with Bradyrhizobium (Zawoznik et al., 1995). Pre-emergence herbicide application can help control weeds, to some extent, during the early crop growth stage. Soybean undergoes heavy weed competition especially in the early growth stages. Crop-weed competition is minimized by pre-emergence herbicide spray, resulting in decreasing weed dry matter and increasing crop yield (Jeyabal et al., 2001; Mohamed, 2004; Sha et al., 2004). Regarding chemical weed control, selective herbicides may be effective against annual weeds and achieve high soybean and legume yield, such as butralin (Hassanein et al., 2000; El-Metwally & Saad El-Din, 2003), prometryn (Sha et al., 2004; Abd El-Razik, 2006) and oxadiargyl (Dobrzanski et al., 2001). Hence, two field experiments were conducted to examine the effects of different herbicides, applied at pre-emergence on weed infestation, nodulation, growth, yield and yield attributes of soybean plants.

MATERIALS AND METHODS

Two field experiments were conducted at the experimental farm of the National Research Centre at Shalakan, Kalubia Governorate, Egypt (30.19 N, 31.16 E), in the 2006 and 2007 seasons. The soil texture was clay loam (organic matter 1.91%, total N 0.09%, available P 16 ppm and pH 7.73) and the preceding crop sown was faba bean in both seasons. The experiments were laid out in a randomized complete block design with 11 treatments and four replicates. The treatments consisted of prometryn, oxadiargyl and butralin, two hand hoeings {20 and 40 days after sowing (DAS)} and nonweeded (control). Prometryn herbicide [Gesagard 500 FW, N, N-bis (1-methylethyl-6-(methylthio)-1, 3, 5-triazine – 2, 4-diamine] at the rate of 0.75, 1.5 and 2.25 kg ha^{-1} (a.i.), oxadiargyl [Topstar 400 SC, 3-[2, 4-dicloro-5-(2-Propynyloxy) phenyl]-5-(1, 1-dimethylethyl)-1, 3, 4, oxdiazol-2(3H)-one] at the rate of 240, 480 and720 g ha^{-1} (a.i.), and butralin [Amex, 820, 4-(1, 1dimethylethyl)-N-1-methyl propyl)-2, 6-dinitrobenzenamine] at the rate of 1.20, 2.40 and 3.36 kg ha^{-1} (a.i.) were sprayed on the soil surface as pre-emergence immediately before irrigation, using Knapsack sprayer with one nozzle boom and 476 liter water ha^{-1} as carrier. The 10.50 m^2 experimental unit area contained 5 ridges (3.5 m long and 3 m wide).

After application of the pre-emergence herbicides, all the experimental plots were irrigated. When soil moisture became adequate (3-4 days later), the seeds of soybean (*Glycine max*) cv. Giza 111 were sown on hill 20 cm apart in both sides of the ridge. Sowing dates were 8th and 10th June in the 1st and 2nd seasons, respectively. After complete germination, soybean seedlings were thinned to secure two plants per hill. The first irrigation was carried out 21 days after sowing. Fertilizers N, P and K were applied during soil preparation and before sowing. Nitrogen fertilizer was 36 kg N ha^{-1} as ammonium sulfate (20.6% N). Phosphorus fertilizer was applied in the form of calcium superphosphate (15.5% P_2O_5) at the rate of 357 kg ha^{-1}. Potassium sulfate was applied at the rate of 60 kg K_2O ha^{-1}. All recommended agricultural practices were adopted throughout the two seasons.

Weeds were hand pulled from one square meter of each plot at 70 DAS and fresh weight of broadleaves, grasses as well as total weeds was estimated. Dry weight of each group was recorded after oven drying at 70 °C for 72 hrs.

At 70 DAS, samples of five random plants were taken from each experimental plot. Each plant was excised at ground level from the top (leaves, stems and reproductive organs) and the underground portion (roots). The roots were washed carefully to remove soil and the nodules were separated from the roots and counted. To remove soil particles and plant debris from the root surface, the underground portion was washed carefully under tap water. Shoots, root nodules and roots were oven-dried at 70 ºC for 72 hrs and their dry weight was measured. The oven dried shoots were ground to pass a 0.5 mm sieve to estimate nitrogen (N) content. Total N was determined as outlined by AOAC (1980).

After maturity, soybean plants were harvested from one middle ridge of each plot on 17th and 25th October in the 1st and 2nd seasons, respectively, to estimate pod number $plant^{-1}$, pod weight $plant^{-1}$ (g), seed number $plant^{-1}$, seed yield $plant^{-1}$ (g), seed yield (kg ha^{-1}), biological yield $plant^{-1}$(g) and 100-seed weight (g). The seeds were ground to pass a 0.5 mm sieve to estimate N and oil contents. Total nitrogen content of the seeds was determined according to AOAC. (1980). N values were multiplied by 6.25 to calculate total crude protein (TCP). Oil percentage in soybean seeds was measured by extraction using Soxhlet apparatus with Hexane as an organic solvent, as outlined by AOAC. (1980).

Variance analysis was performed for each trait in both seasons and the combined analysis over seasons after testing the homogeneity of error variances was carried out according to the procedure outlined by Gomez & Gomez (1984), using MSTATC version 2.1 (Michigan State University, USA) statistical package design. The significant differences between treatments were compared with the critical difference at 5% probability by the Duncan's test.

RESULTS AND DISCUSSION

Weed species

The dominant weeds in the two experimental seasons were mostly broad-leaved, namely, Common purslane (*Portulaca oleraceae*), Nalta jute (*Corchorus olitorius*) and Venice mallow (*Hibiscus trionum*) in addition to grassy Jungle rice (*Echinochloa colonum*), Bermudagrass *(Cynodon dactylon)* and Purple nutsedge (*Cyperus rotundus*).

Effects on weeds

Data presented in Table 1 reveals that the fresh and dry weights of broadleaved, grassy and total weeds were significantly reduced by weed management practices, compared to the nonweeded treatment. In this regard, two hand hoeings achieved the highest weed depression expressed in the lowest dry matter of the mentioned weed groups. Reduction percentage in dry matter recorded relative to weed check treatment amounted to 98.3, 92.6 and 96.9% in broad-leaved, grassy and total weeds, respectively. Combined data also reported that herbicide application reduced significantly the dry weight of broad-leaved, grassy and total weeds, compared to the nonweeded treatment. The percentage of reduction in broadleaved weed dry matter due to application of prometryn (2.25 kg ha^{-1}), oxadiargyl (720 g ha^{-1}), oxadiargyl (480 g ha^{-1}), prometryn (0.75 kg ha^{-1}) were 90.6, 90.3, 88.48 and 87.7%, respectively, compared to nonweeded check. The reduction percentages, also in dry weight of grassy weeds obtained by application of butralin (3.36 kg ha^{-1}), oxadiargyl (720 g ha^{-1}), butralin (2.40 kg ha^{-1}) and oxadiargyl (480 g ha^{-1}) were 89.5, 85.9, 79.5 and 77.1%, respectively, compared to the nonweeded treatment. Dry matter reduction percentages of total weeds were obtained from the application of oxadiargyl (720 g ha^{-1}), prometryn (2.25 kg ha^{-1}), oxadiargyl (480 g ha^{-1}) and prometryn (1.5 kg ha^{-1}) were 89.2, 86.0, 85.5 and 82.2%, respectively, compared to control.

Several reports have confirmed that hoeing twice is the most effective weed control practice for reducing weed dry matter accumulation in soybean fields (Mandloi et al., 2000, Singh & Jolly, 2004; Kushwah & Vyas, 2005). Applied herbicides, i.e., prometryn, oxadiargyl and butralin vary in their weed control target. Prometryn effectively controls broadleaves with moderate mortality impact on grassy ones, and butralin controls grassy and some broadleaves while oxadiargyl is an active pre-emergence herbicide on both annual monocotyledons and dicotyledons, acting at germination as the new shoots come in contact with treated soil particles (Dickmann et al., 1997). Tracchi et al. (1997) and Nikolova & Baeva (2000) reported that oxadiargyl was highly efficient in controlling annual grasses and broad-leaved weeds grown in some field crops (sunflower, rice, faba bean and soybean), and some vegetables (tomato, cabbage, pepper, onion and celery). Thus, oxadiargyl was more effective in controlling total weeds and resulted in the highest reduction of dry matter when compared with prometryn and butralin. The reduction of weed dry weight may be due to the inhibition effect of herbicide treatments on growth and development of weeds. Our findings are consistent with those obtained by Sha et al. (2004) and Behera et al. (2005).

Table 1 - Combined main effects of weed control treatments on fresh and dry weights of broad leaved, grasses and total weeds (g m^{-2}) at 70 DAS

Treatments	Broad leaved g m^{-2}		Grasses g m^{-2}		Total weeds g m^{-2}	
	Fresh weight	Dry weight	Fresh weight	Dry weight	Fresh weight	Dry weight
Nonweeded	1542.4 a[1]	144.1 a	294.3 a	51.6 a	1836.7 a	197.3 a
Prometryn 0.75 kg ha^{-1}	300.5 e	28.1 e	110.4 b	19.4 b	410.9 d	47.4 d
Prometryn 1.50 kg ha^{-1}	190.4 g	17.8 g	99.3 c	17.4 c	289.7 f	35.2 f
Prometryn 2.25 kg ha^{-1}	145.4 h	13.6 h	80.6 d	14.1 d	225.9 g	27.7 g
Oxadiargyl 240 g ha^{-1}	264.3 f	24.7 f	100.3 c	17.5 c	364.5 e	42.3 e
Oxadiargyl 480 g ha^{-1}	177.3 g	16.6 g	68.5 e	11.8 e	245.7 g	28.6 g
Oxadiargyl 720 g ha^{-1}	150.3 h	14.0 h	41.1 g	7.3 f	191.4 h	21.3 h
Butralin 1.20 kg ha^{-1}	520.5 b	48.7 b	92.4 c	16.2 c	612.8 b	64.8 b
Butralin 2.40 kg ha^{-1}	498.6 c	46.6 c	60.3 f	10.6 e	558.9 c	57.2 c
Butralin 3.36 kg ha^{-1}	370.7 d	34.7 d	30.5 h	5.4 g	401.2 d	40.0 e
THH	25.4 i	2.4 i	21.5 i	3.8 h	46.9 i	6.2 i

1/ Means followed by a common letter within a column are not significantly different using the Duncan's test ($p < 0.05$).

Effects on soybean plant

Nodulation and nitrogen content of soybean

Herbicide application can bring undesirable consequences to soil microorganisms, depending on the active compound, commercial formulation, dose (Royuela et al., 1998), climatic conditions and soil type (Silva et al., 2003). Data presented in Figure 1 show that number and dry weight of nodules/plant significantly increased with two hand hoeings and nonweeded treatments, compared to other treatments. Number of nodules significantly decreased as doses exceeded the recommended prometryn (2.25 kg ha^{-1}), oxadiargyl (720 g ha^{-1}) and butralin (3.36 kg ha^{-1}) rates. Decreases in number of nodules at excess rates were 51.6, 54.3, and 40.3%, respectively, compared with hand hoeing twice, whereas the corresponding decreases in number of nodules at the recommended rates were 39.1, 36.4 and 39.9% for the same herbicides, respectively, compared with hand hoeing twice. The same trend was found in nodule dry weight per plant. These results indicated that nodulation of soybean plants is sensitive to the recommended rates and to rates higher than the recommended of the three tested herbicides, as confirmed by González et al. (1996), the risk of herbicide toxicity to micro-organisms may be higher since the metabolism products can inhibit biochemical processes related to symbiosis between plants and micro-organisms. Results also indicated that there was no significant effect between hand hoeing twice and nonweeded treatment on dry weight and number of nodules per plant^{-1}. Similar results were obtained by Attia (2002), Singh & Wright (2002) and El-Metwally & Shalby (2007).

The application of oxadiargyl at the rate of 240 g ha^{-1} resulted in the highest shoot N (%), exceeding the nonweeded by 45% (Figure 2). Also, oxadiargyl at the rate of 480 g ha^{1} provided the highest value of shoot N (g plant^{-1}), compared to all the other treatments (Figure 2). All the applied herbicides increased significantly shoot N (%) compared to either two hand hoeings or nonweeded treatment. A similar result was found in regard to shoot N (g plant^{-1}), except for two hand hoeings since that treatment scored significantly higher shoot DW compared with all the other treatments. The increase in shoot N expressed as % and g plant^{-1} may be attributed to the fact that controlling weeds by herbicides resulted in reduced weed-crop competition, consequently improving crop growth.

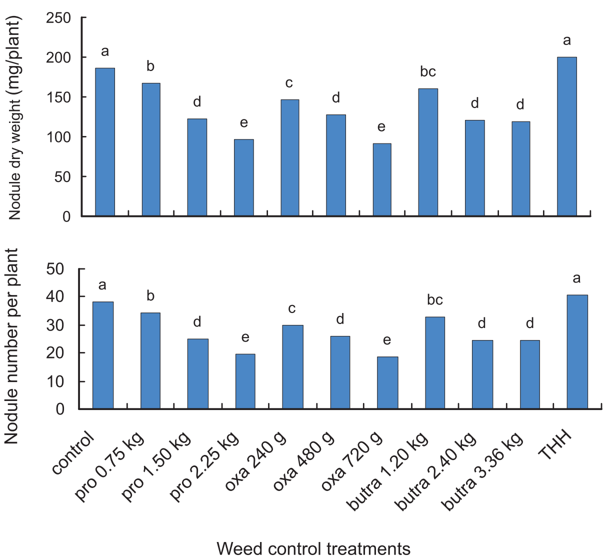

Figure 1 - Combined main effects of weed control treatments on nodule number per plant and nodule dry weight (mg plant^{-1}) of soybean at 70 DAS.

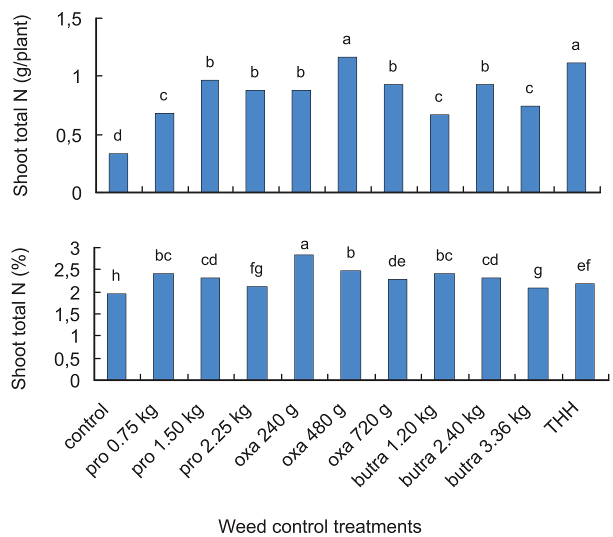

Figure 2 - Combined main effects of weed control treatments on shoot total N (%) and shoot total N (g plant^{-1}) of soybean at 70 DAS.

Soybean growth

Weed management practices had a significant effect on soybean growth (Table 2). Two hand hoeings and all applied herbicides at recommended rates significantly increased plant height, number of branches per plant^{-1}, root, shoot and total dry weight of soybean plants at 70 DAS compared to the other treatments. Application of the previous treatments was effective in controlling weed and consequently competition was limited and lighter, and water and nutrients were available to promote soybean growth compared to other treatments. These results are in agreement with those recorded by Galal (2003) and Mohamed (2004). Results also indicated that all soybean characteristics mentioned above significantly decreased at levels higher than the recommended rates of the herbicides applied.

In general, herbicides significantly decreased growth traits at rates higher than the recommended. Although no visual phytotoxicity by prometryn, oxadiargyl and butralin at the recommended level and at levels higher than the recommended ones were observed, adverse effects on plant growth occurred. This might have been due to the internal herbicide effect on the plant growth processes. All the tested herbicides in this study are known to adversely affect plant photosynthesis (Dodge, 1990; Tomline, 1995). Thus, the decreases observed in the above mentioned traits might be the result of reduced photosynthesis.

Soybean yield, yield components and seed composition

The physiological and yield responses of soybean to a herbicide may vary, and may also depend on geographical location, environmental conditions, soil types, sensitivity of native populations of *Bradyrhizobium japonicum* etc. (Zablotowicz & Reddy, 2007).

Significant differences were observed in function of weed management practices in yield and its attributes (Table 3). Two hand hoeing treatments provided the maximum values in pod number per plant^{-1}, pod weight per plant^{-1} and number of seeds per plant^{-1}, amounting to 140.7, 150.0 and 59.8%, respectively, compared to the nonweeded treatment. In addition, oxadiargyl at the recommended rate 480 g ha^{-1} was the best treatment to promote seed yield (g plant^{-1}), seed yield (kg ha^{-1}) and biological yield (g plant^{-1}) exceeding the unweeded check by 87.3, 85.0 and 88.2%, respectively. In addition, application of prometryn at the rate of 1.5 kg ha^{-1} was the best treatment to increase 100-seed weight (g). On the other hand, oxadiargyl 480 g ha^{-1}, two hand hoeings, prometryn 1.5 kg ha^{-1} and prometryn

Table 2 - Combined main effects of weed control treatments on plant height (cm), branch number plant^{-1}, root dry weight plant^{-1} (g), shoot dry weight plant^{-1} (g), and total dry weight plant^{-1} of soybean at 70 DAS

Treatments	Plant height (cm)	Branch no. plant^{-1}	Root DW plant^{-1} (g)	Shoot DW plant^{-1} (g)	Total DW plant^{-1} (g)
Nonweeded	66.5 d[1/]	1.78 e	2.2 e	17.0 g	19.2 g
Prometryn 0.75 kg ha^{-1}	82.3 abcd	2.22 cde	3.2 cd	28.4 f	31.6 f
Prometryn 1.50 kg ha^{-1}	81.5 bcd	2.67 abc	4.1 ab	41.6 bc	45.7 bc
Prometryn 2.25 kg ha^{-1}	98.8 ab	3.00 ab	4.1 ab	41.7 bc	45.8 bc
Oxadiargyl 240 g ha^{-1}	89.2 abc	2.33 cde	3.6 bc	31.1 ef	34.7 ef
Oxadiargyl 480 g ha^{-1}	99.9 a	3.00 ab	4.1 ab	47.1 ab	51.2 ab
Oxadiargyl 720 g ha^{-1}	95.5 ab	2.55 abc	3.7 bc	41.0 cd	44.7 cd
Butralin 1.20 kg ha^{-1}	74.5 cd	1.87 de	2.8 de	27.8 f	30.6 f
Butralin 2.40 kg ha^{-1}	93.2 ab	2.44 bcd	3.6 bc	40.1 cd	43.7 cd
Butralin 3.36 kg ha^{-1}	92.0 ab	2.44 bcd	3.6 bc	35.4 de	39.0 de
THH	99.9 a	3.11 a	4.6 a	50.9 a	55.5 a

[1/] Means followed by a common letter within a column are not significantly different using the Duncan's test ($p < 0.05$).

Table 3 - Combined main effects of weed control treatments on pod number per plant^{-1}, pod weight per plant^{-1} (g), seed number per plant^{-1}, seed yield (g plant^{-1}), seed yield (kg ha^{-1}), biological yield (g plant^{-1}), 100-seed weight (g), seed protein percentage, seed oil percentage of soybean at harvest

Treatments	Pods no. plant^{-1}	Pods wt. plant^{-1}	Seeds no. plant^{-1}	Seed yield (g plant^{-1})	Seed yield (kg ha^{-1})	Biological yield (g plant^{-1})	100-seed weight (g)	Seed protein (%)	Seed oil (%)
Nonweeded	32.7 g[1/]	18.4 h	79.0 g	13.4 f	3809.5 f	41.4 f	16.8 d	35.6 h	24.1 g
Prometryn 0.75 kg ha^{-1}	52.8 e	30.5 fg	92.1 ef	16.9 d	4826.2 d	52.4 d	20.0 b	36.0 gh	24.7 f
Prometryn 1.50 kg ha^{-1}	63.4 c	38.9 c	119.8 b	24.1 a	6857.1 a	75.6 a	22.0 a	38.1 a	26.3 a
Prometryn 2.25 kg ha^{-1}	74.0 b	38.0 c	118.3 b	24.4 a	6830.1 a	74.7 a	19.7 b	37.6 abc	25.7 bc
Oxadiargyl 240 g ha^{-1}	57.8 d	32.6 ef	106.1 d	20.5 c	5714.3 c	63.5 c	17.0 d	37.4 bcd	25.1d ef
Oxadiargyl 480 g ha^{-1}	76.5 ab	42.7 b	120.6 b	25.1 a	7047.6 a	77.9 a	21.2 a	37.8 ab	26.0 ab
Oxadiargyl 720 g ha^{-1}	60.5 cd	36.5 cd	118.4 b	22.5 b	6285.7 b	69.6 b	19.2 b	37.0 cde	25.5 bcd
Butralin 1.20 kg ha^{-1}	42.8 f	28.0 g	95.1 e	15.4 e	4190.5 e	47.6 e	18.0 c	36.5 efg	24.9 ef
Butralin 2.40 kg ha^{-1}	60.2 cd	34.7 de	110.5 c	21.3 bc	6000.0 bc	66.0 bc	18.0 c	36.9 def	25.4 cde
Butralin 3.36 kg ha^{-1}	59.3 d	33.5 e	91.0 f	20.4 c	5714.3 c	62.4 c	16.9 d	36.3 fg	24.8 f
THH	78.7 a	46.0 a	126.2 a	24.6 a	6952.4 a	76.4 a	19.5 b	37.8 ab	26.3 a

[1/] Means followed by a common letter within a column are not significantly different using the Duncan's test ($p < 0.05$).

2.25 kg ha^{-1} treatments had the highest seed yield (kg ha^{-1}) compared with the other treatments. These superior treatments increased seed yield over unweeded treatment by 85.0, 82.5, 80.0 and 79.3%, respectively.

Data in Table 3 show that total crude protein percentage and oil percentage in soybean seeds were affected by weed management treatments. Prometryn at the rate of 1.5 kg ha^{-1}, followed by two hand hoeings, produced the highest protein and oil percentage of seeds compared to other weed control treatments. Similar results were obtained by Mohamed (2004) and EL-Metwally & Shalby (2007).

Increase due to application of hand hoeing twice over the weedy check was reported in number of branches and pods per plant^{-1} (Kushwah & Vyas, 2005), in pod weight per plant^{-1} (Jain et al., 2000) and seed yield ha^{-1} (Vyas et al. 2000; Pandya et al., 2005). Results also indicate that application of all tested herbicides at doses over the recommended rates significantly decreased yield and related attributes of soybean plants. This result may be due to the effect of the herbicide on the internal growth processes in the plants, reflected in decreasing soybean yield and its components.

The enhancement of soybean yield and its components over the weeded treatments may be attributed to their high efficiency in eliminating the weeds (Table 1) and consequently decreasing their competitive ability against crop plants. In addition, the important role hoeing plays in improving soil properties, such as soil structure, aeration, water penetration and availability of some nutrients. In other words, these results may be due to less competition for nutrients, water and light by limiting weed infestation with two hand hoeings or herbicidal treatments, as a result of nutrient uptake.

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