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Effect of Rhizobial Inoculation and Weed Control on Weed Species, Bactria Nodulation and Peas Yield

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ABSTRACT

Most of farmers in Kafr El-Sheikh area accustomed to grow pea as cash vegetable crop in the short period lied between summer and winter crops before growing summer season and they need to control weeds in such crop. Thus, this investigation was carried to study the response of pea plant Master B, variety and their associated weed in two field experiments were during 2013/2014 and 2014/2015 winter seasons at Sakha Horticultural Research Station Farm, Kafr El-Sheikh Governorate. A split plot in a randomized complete blocks design with four replications was used. Where the response of pea plants, two inoculated with the rhizobium bacteria and some weed control treatments. The main plots included rhizobium bacteria inoculation and uninoculated control, the sub plots included eight weed control treatments i.e pendimethalin at 1.7L/fed, pendimethalin at 1.25L/fed plus hand hoeing once, pendimethalin at 1.0 L/fed plus hand hoeing twice; butralin at 2.5L/fed; butralin at 2.00 L/fed plus hand hoeing once; butralin at 1.0 L/fed plus hand hoeing twice, hand hoeing twice and untreaded control. The main findings in this study were as follow: Rhizobial inoculation with pea seeds caused significant increases in both seasons in number of nodules plant^{-1}, fresh, dry weight of nodules plant^{-1} and increased yield ton/fed by (58.1, 37.5, 37.5 and 16.7%), in 2013/2014 season and (57.9, 35.3, 38.5 and 22.7%), in 2014/2015 season, respectively.This was accompanied improving pea plant growth characteristics caused indirection suppressed on the dry weight of weeds, than non-inoculation seeds treatment condition and increasing competitiveness of pea plant. There is no approves inhibition effects on bacterial nodules formation the use herbicides on number of nodules plant^{-1}, fresh and dry weight of nodules plant^{-1} except with pendimethalin at 1.7L/fed, which decreased the fresh and dry weight of nodules plant^{-1} by (46.7 and 37.5%), in 2013/14 season and, (47.1 and 41.7%), in 2014/15 season. All weed control treatments reduced dry weight of broadleaf, grassy and total weeds due to weed species susceptibility to herbicidal the use herbicidal as compared with untreated control. The effective weed control treatments could be arranged in a descending order according to their depressing the dry weight of total weeds increasing peas yield and its components as follows: butralin at 2.00 L/fed plus hand hoeing once and increased pea yield by (72.7 and 76.9%), in 2013/14 season and (70.4 and 75.0%), in 2014/15 season than untreated check. The effect of interaction between with rhizobial inoculation and weed control treatments on bacterial nodules were statistically significant in both seasons. Most herbicidal treatments under uninoculation condition inhibited to somewhat number of nodules/plant, fresh and dry weight of nodules/plant except with some treatments which were similar its untreated check and rhizobial inoculation with herbicidal treatments can be help bacterial nodules recovery from the sides effects of herbicide. Meanwhile, the previous interaction gave 95% weed control accompanied increase in pea yield ton/fed with applying rhizobial and adding, butralin at 2L/fed plus hand hoeing once, where improved of weed control and enhancing pea growth with rhizobial inoculation other interaction were discussed as show in manuscript of paper. The dry weight of total weeds biomass was correlated indicating negative with pea yield indicating to the severity of weed competition on pea yield and its components which may be attributed directly to the improvement of weed control in one side and enhancing the grow of pea/plants by increasing effective bacterial nodules in fixing nitrogen in the other sides. Thus, we can recommend farmers to inoculate pea seeds with rhizobial inoculation and use the proper herbicidal treatments to control weeds in pea field as good alternative to mechanical hand hoeing.

Keywords: *Pisum sativum* L., Inoculation, Herbicides, Weeds, Pea and green pods yield

INTRODUCTION

Peas (*Pisum sativum* L.), a cool weather crop, is one of the most popular crops grown in Egypt due to its high contents of protein, carbohydrates, vitamins and minerals. It can grow throughout different types of soils ranging from the light sandy loom to the heavy clay in texture. Most pea cultivars are grown for fresh and/or dry seeds. The total cultivated green pea area was 42502 feddans with mean productino 4.25 ton/fed (Anonymous, 2014[1]*). The pea cultivar used (Master B) is a short growing period, determinate growth habit and low fertilizer requirements (Fayad, 2004). Supplementtion or substitution inorganic N with organic sources become so urgent. Significant effects of untraditional fertilizers, particularly the biofertilizers, on growth and yield of legumes have been reported by several investigators (Bin Ishaq, 2002, on pea). In most cultivated areas of Egypt, pea is subjected to some problems including reduction of nodules formation due to less prevalent of *Bradyrhizobium lupinous*. This problem adversely affects its biological nitrogen fixation, consequently the plant growth and the cost of production due to the increase of mineral fertilization. Many investigators reported that *Rhizobium* increased plant growth; yield components and chemicals composition of legumes plants (El Sayed *et al*. 2012, on pea). El-Waraky *et al*. (2013) on pea, and Masoud and Mehesen (2013) on cowpea. They showed that significant positive effects on dry seed yield and its components due to the inoculation of seeds with different biofertilizer types. In addition, herbicides may also influence the growth of rhizobia.

Weeds are a major problem in bean and pea production in the world. Weeds can reduce yields through direct competition for light, moisture, and nutrients. Early season weed control is extremely important, and a major emphasis on control should be made during this period. Weeds presented reduce the harvesting efficiency and increase of mechanical damage on the pods. 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 pea productivity. The advantages of herbicide use are high efficiency in weed control, compared to other available weed control methods. Despite the satisfactory weed control results, many questions remain on the effect of herbicides on the N2 fixation process, since the soybean crop is dependent on symbiosis with *Bradyrhizobium sp.* (Zawoznik *et al*., 1995). Pre-

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emergence herbicide application can help control weeds, to some extent, during the early crop growth stage. Crop-weed competition is minimized by pre-emergence herbicide spray, resulting in decreasing weed dry matter and increasing crop yield (Mohamed, 2004). Regarding chemical weed control, selective herbicides may be effective against annual weeds and achieve high legumes yield, such as butralin. In addition, herbicides may also influence the growth of rhizobia. (El-Metwally and Saad El-Din, 2003) Herbicides may have negative effects on the growth of rhizobia (Clark and Mahanty 1991; Martensson 1992), although other reports have shown no adverse effects (Gonzalez *et al.* 1996). Herbicides may influence nodulation and biological nitrogen fixation in legumes either by affecting rhizobia or the plant and/or both. There is need to study thus separate the possibility of the direct effects of herbicides on rhizobia. The effects of herbicides on nodulation and nitrogen fixation on plant growth have been reported previously. (Singh and Wright, 1999), showed that herbicides adversely affected nodulation, nitrogenous activity and plant growth. (Maheswari *et al*., 2016) inducated that herbicides are strong chemical products that not only action their target weeds but may also display significant toxicity to other organisms. Further study was extended to test effect herbicides under field conditions on the growth of Rhizobia.

Herbicides commonly used for controlling weeds in peanuts were evaluated under fields at recommended levels, had no adverse effect on nodulation rate, nitrogenase activity, total nitrogen of peanut tops or pod yield, compared with control (inoculated plant and without herbicide) Kishinvsky *et al.,* (1988). Pre-emergence herbicides are used most frequently in a green pea culture because they eliminate competition between crop plant and weeds even at the critical early growth stage.The herbicides have possible targets in both the legumes and symbiotic bacteria. (Wágner and Nádasy, 2006).

The objective of the present study is to investigate the effect of inoculation with rhizobia and direct effects of herbicides (pendimethalin and butralin) on growth, green pods and dry seed yield and seed quality of the pea plants.

MATERIALS AND METHODS

This work was carried out at Sakha Horticulture Research Station, Kafr El-Sheikh Governorate, during the winter seasons of 2013/2014 and 2014/2015, to investigate the influences of seed inoculation with rhizobia, effects of herbicides and their interactions on vegetative characters, green pods and seed yield and their components of pea (*Pisum sativum* L.) Master B cultivar. Soil texture of the experimental site in both seasons was clay loam (Table 1).

Table 1. Mechanical and chemical analysis of soil in experimental fields, in 2013/14 and 2014/15.

Season	Mechanical analysis			Texture	pH*	EC** dSm^{-1}	OM %	Available elements(ppm)		
	Sand %	Silt %	Clay %					N	P	K
2013/14	21.65	25.14	53.21	clay loam	8.05	2.1	1.70	22	6.1	280
2014/15	24.72	26.11	49.17	clay loam	8.21	2.4	1.60	19	5.8	214

Each experiment indicated sixteen treatments which were arranged in a split plot design with four replicates as follows:

I. Main plots: 1- Rhizobia inoculation.
2-Uninoculated control.

Effective selected strain of pea rhizobia *Rhizobium leguminosarum* biovar viceae was kindly obtained from Biological Nitrogen Fixation Unit., Dept. of Soil Microbiology at Sakha Agricultural Research Station, ARC. The biofertilizer rhizobia was used at the rate of 10g/ kg^{-1} seeds. Seed inoculation was performed by adding an adequate amount of distilled water and Arabic gum and mixed thoroughly with the seeds just before sowing. Uninoculated seeds (of the control treatment) were mixed with distilled water and Arabic gum.

II. Sub plots (weed control treatments namely):-

A. Pendimethalin [*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine], known commercially as Stomp Extra 45.5% CS, was soil-applied at 1.7 L/fed, after sowing and before irrigation.
B. Pendimethalin known commercially as Stomp Extra 45.5% CS, was soil-applied at 1.25 L/fed, after sowing and before irrigation, followed by one hand hoeing at 18 days from after sowing.
C. Pendimethalin known commercially as Stomp Extra 45.5% CS, was soil-applied at 1 L/fed, after sowing and before irrigation, followed by two hand hoeing at 18 and 30 days from sowing.
D. Butralin [4- (1, 1- dimethylethyl) - *N*- (1-methylpropyl) - 2,6-dinitrobenzenamine], known commercially as Amex 48% EC, was soil-applied at 2.5 L/fed, after sowing and before irrigation.
E. Butralin known commercially as Amex 48% EC, was soil-applied at 2 L/fed, after sowing and before irrigation, followed by one hand hoeing after 18 days from sowing.
F. Butralin known commercially as Amex 48% EC, was soil-applied at 1 L/fed, after sowing and before irrigation, followed by two hand hoeing at 18 and 30 days from sowing.
G. Hand hoeing (twice) at 18 and 30 days from sowing.
H. Untreated check.

All tested herbicides were applied by CP3 knapsack sprayer equipped with a single nozzle boom which was used and spray solution volume was 200 L of water/fed.

The sub plot area was 10.5 m2 contains five ridges 3.5 m length and 60 cm apart. The distance between hills was 25 cm apart. Seedlings were thinned to secure the required number of plants two plants per hill after three weeks from sowing before the 2nd irrigation. Sowing dates were 29 and 25 of November in the first and second seasons, and harvested once on 14 and 10 February for the both two seasons, respectively. Superphosphate (15% P2O5) was broadcasted during soil preparation at 200 kg/fed, both potassium sulphate ٤٨% K2O at 100 kg/fed and ammonium sulphate 20 %at 200 kg N/fed applied in two equal doses at 3 from 5 weeks after sowing. The other normal agricultural practices, i.e. irrigation, insects and disease control, were carried out according to the officinal recommendations. All agronomic practices such as land

preparation, fertilization and irrigation were done as recommended during the two seasons.

Data recorded:

1- Species susceptibility to herbicides:

The susceptibility of weeds species to all herbicides used was measured at 45 days from sowing depending on the reduction percentage of the dry weight of each species compared to the un-weeded check according to the scale mentioned by Frans and Talbert (1977) as follow:

1-Susceptible (S) = > 90 %.
2-Moderately susceptible (MS) = 80 - 89 %.
3-Moderately tolerant (MT) = 60 - 79 %.
4-Tolerant (T) = < 60%.

2-Weeds: Weeds were hand pulling at randomally from one square meter of each plot after 45 and 60 days from sowing and classified into following group: Broadleaf weeds (g/m2), grassy weeds (g/m2) and total weeds (g/m2). The dry weight was determined as (g/m2) after drying in a forced draft oven at 70 C° for 48 hrs, then weighed.

3-Nodulation: At 70 DAS, samples of five random plants were taken from each plot plants uprooted nodules were oven-dried at 70 ºC for 72 hrs, was measured number of nodules per plant^{-1}, fresh and dry weight of nodules plant^{-1}(g).

4. Vegetative growth traits:

At 60 days from sowing the following data were recorded: Total chlorophyll content of leaves was measured by the SPAD-501, a portable leaf chlorophyll meter (Minolta) was used for greenness measurements (Marquard and Timpton,1987) on fully expanded fifth leaf from the shoot tip leaves without destroying them. Plant height (cm), number of leaves plant-1, number of branches plant-1, leaf area plant-1 (cm2) and plant fresh weight plant-1.

٥. Green pods yield and its components : the plants of the second and third ridges were allocated to measure the following data, i.e., number of green pods plant^{-1}, weight of green pod plant-^{1} (g), number of seeds pod^{-1}, weight of seeds pod^{-1} (g) and total green pods yield plant^{-1} (g) and feddan^{-1} (ton).

Correlation study:

Simple correlation matrix was carried out for the two seasons to investigate the relationship between dry weight of different weed categories and pea seed yield and its components according to Steel and Torrie (1980).

All obtained data were statistically analyzed using COSTAT Software (1985), and means were compared according to Duncan's multiple range test (1955).

RESULTS AND DISCUSSION

Effect of inoculation with rhizobia:

1. On weeds:

Data in Table 2 indicated that the inoculation of pea seeds with rhizobia has significant reducing on the dry weight of total annual weeds (g/m^2) in both survys in 2014/15 season but, in 2013/14 season was significant on the dry weight broadleaf weeds only. The reduction percentages in the dry weight of the total annual weeds at 45 and 60 DAS were reached to 58.9 and 45.1%, respectively, in the second season, as compared to uninoculated treatments. It is appear that rhizobia inoculation to be plants enhanced its completive ability against weeds. The results are akin to those reported by Vyas and Jain (2003).

Table 2. Effect of inoculation with rhizobia on dry weight of annual broadleaf, grassy and total weeds, 45 and 60 (DAS) days after sowing in pea crop during 2013/14 and 2014/15 seasons.

Treatments	Dry weight of weeds (g/m^2) At 45 (DAS)			At 60 (DAS)		
	Grassy weeds	Broadleaf weeds	Total weeds	Grassy weeds	Broadleaf weeds	Total weeds
	2013/14 season					
Inoculation with rhizobia	49.66	26.49 b	76.15	270.6	322.4	593.0
Uninoculated (control)	51.86	36.14 a	87.99	283.1	332.7	615.8
F test	NS	*	NS	NS	NS	NS
	2014/15 season					
Inoculation with rhizobia	61.45 b	101.5 b	162.9 a	161.2b	160.5 b	321.6b
Uninoculated (control)	119.9 a	277.2 a	397.1 b	221.8 a	363.5 a	585.3a
F test	**	**	**	*	**	**

Values having a similar letter, within a comparable group of means, are not significantly different, using revised LSR. test at 0.05 level

2. Bactrial nodules:

Data in Table 3 indicated that the inoculation of pea seeds with rhizobia, caused a significant increases in number of nodules plant^{-1}, fresh and dry weights of nodules plant^{-1}, (58.1, 37.5 and 37.5 %, respectively, in the first season and 57.9, 35.3 and 38.5%, respectively, in the second season), compared with the uninoculated treatment. The beneficial effects of the rhizobia on inodulation due to related to enhance nitrogen fixation which by symbiotic N2–fixing bacteria on the morphology and/or physiology of the root system which promoted the vegetative growth to go forward. These results were in agreement with those obtained by Bin Ishaq (2002) and El–Waraky *et al.* (2013) on peas.

Table 3. Effect of inoculation with rhizobia on number of nodules/plant, fresh and dry weights of nodules pea per plant in 2013/14 and 2014/15 seasons.

Treatments	No. of nodules plant^{-1}	Fresh weight of nodules plant^{-1}(g)	Dry weight of nodules plant^{-1}(g)	No. of nodules plant^{-1}	Fresh weight of nodules plant^{-1}(g)	Dry weight of nodules plant^{-1}(g)
	٢٠١3/1٤ season			٢٠١4/15 season		
Inoculation with rhizobia	83.6 a	1.6 a	0.8 a	86.9 a	1.7 a	1.3 a
Uninoculated (control)	35.1 b	1.0 b	0.5 b	36.5 b	1.1 b	0.8 b
F. test	**	**	**	**	**	**

Values having a similar letter, within a comparable group of means, are not significantly different, using revised LSR test at 0.05 level

3. On vegetative growth characters:

Data in Table 4 indicated that the inoculation of pea seeds with rhizobia, has a highly significant increase in plant height (5.6 and 6.2%), number of leaves plant^{-1} (21.4 and 20.3%), number of branches plant^{-1} (25 and 33%), chlorophyll content (2.3 and

2.9%), leaf area plant^{-1} (6.5 and 16.6%) and plant fresh weight plant^{-1} (5.5 and 4.9%), in the two seasons respectively, compared with the uninoculated treatment. The beneficial effects of the rhizobia on the above mentioned growth traits may be related to the nitrogen fixed which increased nutrition status and the enhancing effects of symbiotic N_2–fixing bacteria on the morphology and/or physiology of the root system which promoted the vegetative growth to go forward. Moreover, Noel *et al.* (1996) indicated that the non–symbiotic N_2–fixing bacteria, rhizobia strain, produced adequate amounts of IAA and cytokinins which increased the surface area per unit root length and enhanced root hair branching with an eventual increase in the uptake of nutrients from the soil. Also, results reported by Bin Ishaq (2002); El–Waraky *et al.* (2013) on peas, and Masoud and Mehesen (2013) on cowpea confirmed our findings concerning the stimulating effects of rhizobia on vegetative growth characters.

Table 4. Effect of inoculation with rhizobia on vegetative growth characters in 2013/14 and 2014/15 seasons.

Treatments	Plant height (cm)	No. of leaves plant^{-1}	No. of branches plant^{-1}	Chlorophyll content SPAD Unit	Leave area plant^{-1} (cm^2)	Fresh weight (g) plant^{-1}
2013/14 season						
Inoculation with rhizobia	42.7 a	18.7 a	1.6 a	39.4 a	410.8 a	81.6 a
Uninoculated (control)	40.3 b	14.7 b	1.2 b	38.5 b	384.1 b	77.1 b
F. test	**	**	**	*	**	**
2014/15 season						
Inoculation with rhizobia	45.1 a	20.7 a	1.8 a	40.5 a	506.6 a	85.4 a
Uninoculated (control)	42.3 b	16.5 b	1.2 b	39.3 b	422.5 b	81.2b
F. test	**	**	**	**	**	**

Values having a similar letter, within a comparable group of means, are not significantly different, using revised LSR test at 0.05 level

4. On green pods yield and its components:

Table 5 indicated clearly that there were significant increments in number of seeds pod (9.8 and 11.6%), weight of seeds per pod (11.8 and 16.7 %) and total yield of green pods per plant (20.2 and 21.6%), total yield of green pods per fed. (16.7 and 22.7%) were obtained as a result of seed inoculation with the rhizobia than those of the uninoculated control, in both seasons, respectively. The detective positive effects of rhizobia inculation on pea yield (Table 5) might be related to its beneficial effects on vegetative growth characters (Table 4), which probably supplied more photosynthates and hence might help in increasing yield potential, as mentioned by Jagnow *et al.* (1991). The present results agreed to a great extent with those reported by Chauhan *et al.* (1996), for increased significantly number of pods plant^{-1} and seed yield compared with the control treatment. Bin Ishaq (2002) showed significant positive effects on dry seed yield and its components of pea due to the inoculation of seeds with different biofertilizer types. Similar findings were reported by Masoud and Mehesen (2013) on cowpea and El–Waraky *et al.* (2013) on pea.

Table 5. Effect of inoculation with rhizobia on green pods yield and its components of pea plants in 2013/14 and 2014/15 seasons.

Treatments	No. of green pods Per plant [1]	Weight of green pod (g)	No. of seeds Per pod	Weight of seeds per pod (g)	Total green pods yield Per plant (g)	Per feddan (ton)
2013/14 season						
Inoculation with rhizobia	10.2	5.2	8.1a	3.4	54.9a	1.8a
Uninoculated (control)	9.4	4.5	7.3b	3.0	43.8b	1.5b
F. test	NS	NS	**	**	*	*
2014/15 season						
Inoculation with rhizobia	11.7a	5.5	8.6a	3.6a	66.2a	2.2a
Uninoculated (control)	10.2b	4.9	7.6b	3.0b	51.9b	1.7b
F. test	*	NS	**	*	*	**

Values having a similar letter, within a comparable group of means, are not significantly different, using revised LSR test at 0.05 level

Effect of herbicides:

1.On weeds:

The predominant annual weeds in the experimental plots:

The common weed species, in the experimental sites, were *Phalaris minor* (as annual grassy weed); *Ammi majus, Beta vulgaris, Chenopodium murale, Medicago intertexta, Melilotus indicus, Sonchus oleraceus and Portulaca oleracea* (as annual broadleaf weeds).

The susceptibility of the annual weed species to the herbicides used:

The susceptibility scores of eight weed species to six herbicidal treatments according to the scale used by Frans and Talbert (1977) depending on the reduction % of the dry weight of each weed species in g/m^2 compared with untreated check as mentioned, through 2013/14 and 2014/15 seasons Table 6, *Ammi majus, Beta vulgaris, Chenopodium murale, Medicago intertexta, Melilotus indicus, Sonchus oleraceus and Portulaca oleracea* (as annual broadleaf weeds) and *Phalaris minor* (as annual grassy weeds) were susceptible (S) and moderate susceptible (MS) to butralin at 2L/fed plus hand hoeing once and pendimethalin at 1.25L/fed plus hand hoeing once with ranged between 86-97%. The other herbicides as pendimethalin at (1.7L/fed), pendimethalin at 1.L/fed plus hand hoeing twice, butralin at 1.0L/fed plus hand hoeing twice and butralin at 2.5L/fed approximately gave the moderate susceptible (MS) to the previous weeds species meaning that there herbicides had wide spectrum of weed control. Butralin at 2L/fed + hand hoeing once, gave controlling percentage for (*Rumex dentatus*) by 95% and 92%, (*Anagallis arvensis*) by

90% and 92%, (*Malva parviflora*) by 96% and 94%, *(Chenopodium murale*) by 91% (S) and 96% (S), *(Portulaca oleracea)* by 91% (S) and 97% (S), *(Beta vulgaris*) by 97% (S) and 94% (S), *(Ammi majus)* by 90% (S) and 92% (S) and *(Mililotus indica*) by 95% (S) and 97% (S) as annual broadleaved weeds and 91% (S) and 90% (S) for *(Phalaris minor)* as annual grassy weed in both seasons, respectively. Pendimethalin at 1.25L/fed plus hand hoeing once, gave controlling percentage for (*Rumex dentatus*) by 88% (MS) and 88% (MS), (*Anagallis arvensis*) by 86% (MS) and 89% (MS), (*Malva parviflora*) by 84% (MS) and 85% (MS), *(Chenopodium murale*) by 86% (MS) and 89% (MS), *(Portulaca oleracea)* by *8*9% (MS) and 89% (MS), *(Beta vulgaris*) by 94% (S) and 91% (S), *(Ammi majus)* by 81% (MS) and 87% (MS) and *(Mililotus indica*) by 93% (S) and 93% (S) as annual broadleaved weeds; and 89% (MS) and 89% (MS) for *(Phalaris minor)* as annual grassy weed in both seasons, respectively. The same trend with little differences was observed in weed control treatments pendimethalin at (1.7L/fed), pendimethalin at 1.L/fed plus hand hoeing twice, butralin at 1.0L/fed plus hand hoeing twice, butralin at 2.5L/fed.

Table 6. Susceptibility of annual weed species to herbicides at 45 days after sowing, during 2013/14 and 2014/15 winter seasons.

Weeds species / Herbicides	Controlling % & weeds species susceptibility to herbicidal treatments								
	Species of an annual broadleaf weeds								Species of an annual grassy weeds
	Rumex dentatus	*Anagallis arvensis*	*Malva parviflora*	*Chenopodium album*	*Portulaca oleracea*	*Beta vulgaris*	*Ammi majus*	*Melilotus indica*	*Phalaris minor*
2013/14 season									
Pendimethalin (1.7 L/fed)	80 (MS)	84 (MS)	89 (MS)	89 (MS)	87 (MS)	89 (S)	86 (MS)	91(S)	88 (MS)
Pendimethalin (1.25L/fed) + H.H	88 (MS)	86 (MS)	84 (MS)	86 (MS)	89 (MS)	94 (S)	81 (MS)	93 (S)	89 (MS)
Pendimethalin (1L/fed) + H.H (2)	80 (MS)	81 (MS)	81 (MS)	83 (MS)	89 (MS)	90 (S)	81 (MS)	89 (MS)	85 (MS)
Butralin (2.5L/fed)	80 (MS)	83 (MS)	86 (MS)	82 (MS)	88 (MS)	91 (S)	85 (MS)	90 (S)	87 (MS)
Butralin (2L/fed) + H.H	95 (S)	90 (S)	96 (S)	91 (S)	91 (S)	97 (S)	90 (S)	95 (S)	91 (S)
Butralin (1L/fed) + H.H (2)	80 (MS)	80 (MS)	82 (MS)	83 (MS)	83 (MS)	91 (S)	83 (MS)	90 (S)	86 (MS)
2014/15 season									
Pendimethalin (1.7 L/fed)	87 (MS)	82 (MS)	88 (MS)	86 (MS)	88 (MS)	90 (S)	86 (MS)	91(S)	88 (MS)
Pendimethalin (1.25L/fed) + H.H	88 (MS)	89 (MS)	85 (MS)	89 (MS)	89 (MS)	91 (S)	87 (MS)	93 (S)	89 (MS)
Pendimethalin (1L/fed) + H.H (2)	81 (MS)	80 (MS)	81 (MS)	83 (MS)	86 (MS)	90 (S)	81 (MS)	89 (MS)	85 (MS)
Butralin (2.5L/fed)	87 (MS)	83 (MS)	88 (MS)	87 (MS)	88 (MS)	90 (S)	85 (MS)	90 (S)	86 (MS)
Butralin (2L/fed) + H.H	92 (S)	92 (S)	94 (S)	96 (S)	97 (S)	94 (S)	92 (S)	97 (S)	90 (S)
Butralin (1L/fed) + H.H (2)	81(MS)	81 (MS)	82 (MS)	85 (MS)	82 (MS)	90 (S)	83 (MS)	90 (S)	84 (MS)

H.H: hand hoeing once H.H (2): hand hoeing twice

Data presented in Table 7 showed that all the tested herbicidal treatments significantly decreased the dry weight of broadleaf, grassy and total annual weeds in the two surveys and two seasons. Furthermore, the herbicidal treatments were superior than hand hoeing twice treatment. That is true in two assessments and both seasons. Butralin at 2L./fed plus hand hoeing once, pendimethalin at 1.25/fed plus hand hoeing once, pendimethalin at 1.7L/fed, pendimethalin at 1.L/fed plus hand hoeing twice, butralin at 1.0L/fed plus hand hoeing twice and butralin at 2.5L/fed followed by hand hoeing twice gave the significant reduction on grassy annual weeds by 92.5, 89.9, 88.4, 86.9, 86.2, 82.7 and 74.6%, respectively at 45 days from sowing and 92.4, 89.9, 88.3, 87.0, 86.8, 86.3 and 78.9%, repetitively at 60 days from sowing in first season. Withal, the previous respective treatments gave the redaction percentage on the broadleaved weeds by 87.1, 86.1, 85.1, 84.4, 82.6, 81.7 and 55.1%, respectively, at 45 days from sowing and 92.5, 89.9, 88.4, 87, 86.4, 86.3 and 78.2%, respectively, at 60 days from sowing. The same trend was observed on reduction two categories of the annual weeds in the second season. Butralin at 2L/fed plus hand hoeing once, pendimethalin at 1.25L/fed plus hand hoeing once, pendimethalin at 1.7L/fed, pendimethalin at 1.L/fed plus hand hoeing twice, butralin at 1.0L/fed plus hand hoeing twice and butralin at 2.5L/fed followed by hand hoeing twice gave reduction percentage on the grassy weeds by 95.2, 94.2, 93.1, 88.0, 86.7, 79.9 and 61.5%, in 1st survey, 95.2, 93.4, 90.9, 88.0, 83.0, 76.9 and 63.4%, in 2nd survey, respectively. Meanwhile, the reduction percentage for broadleaved weeds by the previous respective treatments reached to 97.1, 96.4, 93.5, 89.4, 88.4, 84.2 and 70.6%, in 1st survey and 95.2, 94.8, 89.4, 87.7, 87.2, 75.7 and 64.3%, in 2nd survey, respectively. The reduction of weed dry weight may be due to the effect of herbicide treatments on inhibition growth and development of weeds. These findings are in consistent with those obtained by Singh and Wright (2002).

2. Bactrial nodules:

It is clear from Table 8 that the treatments without herbicides gave the highest values of nodules characteristics/ plant^{-1}, in both seasons. The differences were highly significant in both seasons. Hand hoeing twice treatments gave 67.9, 1.4 g and 0.8 g, of number, fresh and dry nodules /plant, respectively, in 1st season and 70.6, 1.6 g and 1.1 g, respectively, in 2nd season. Untreated check was the following treatment on increasing the previous respective nodules characteristics /plant by 64.7, 1.5 g and 0.8g in 1st season and 67.2, 1.7 g and 1.2 g in 2nd season. Whilst, the herbicidal treatments gave a lower and flouted values of nodules characteristic /plant in both season, with one exception by butralin at 2L/fed plus hand hoeing once and/ or twice. These results indicated that nodulation of pea plants is sensitive to the herbicides used in the study, as confirmed by González *et al.* (1996) , Abd El-Hamid and El-Metwally (2008) and Singh and Wright (2002).

Table 7. Effect of some weed control treatments on dry weight of annual broadleaf, grassy and total weeds, 45 and 60 (DAS) days after sowing in pea crop during 2013/14 and 2014/15 seasons.

Weed control treatments (L/fed)	Dry weight of weeds (g/m^2)					
	At 45 (DAS)			At 60 (DAS)		
	Grassy weeds	Broadleaf weeds	Total weeds	Grassy weeds	Broadleaf weeds	Total weeds
	2013/14 season					
Pendimethalin (1.7 L/fed)	23.78 d	16.36 c	40.14 d	135.5 c	159.3 c	294.9 c
Pendimethalin (1.25L/fed) + H.H	20.51 de	15.74 c	36.24 de	116.9 cd	137.4 cd	254.3 cd
Pendimethalin (1L/fed) + H.H (2)	26.82 d	14.68 c	41.50 d	152.9 c	179.7 c	332.6 c
Butralin (2.5L/fed)	28.05 d	18.29 c	47.49 d	159.9 c	187.9 c	347.8 c
Butralin (2L/fed) + H.H	15.39 e	13.51 c	28.90 e	87.73 d	103.1 d	190.9 e
Butralin (1L/fed) + H.H (2)	35.28 c	19.27 c	53.56 cd	151.1c	186.4 c	337.5 c
Hand hoeing twice	51.92 b	47.28 b	99.21 b	245.9 b	297.9 b	543.9 b
Untreated check	204.3 a	105.4 a	309.7 a	1164.6 a	1368.9 a	2533.6 a
F test	**	**	**	**	**	**
	2014/15 season					
Pendimethalin (1.7 L/fed)	24.95 d	54.93 de	79.88 de	55.59 d	95.32 cd	150.9 d
Pendimethalin (1.25L/fed) + H.H	20.79 d	29.87 e	50.66 de	40.57 d	46.22 d	86.79 d
Pendimethalin (1L/fed) + H.H (2)	47.92 cd	97.78 cd	145.7 cd	104.1 cd	110.45 cd	214.5 cd
Butralin (2.5L/fed)	43.12 cd	88.64 cde	131.8 cde	73.31 cd	115.24 cd	188.5 cd
Butralin (2L/fed) + H.H	17.19 d	24.02 e	41.21 e	29.23 d	43.35 d	72.58 d
Butralin (1L/fed) + H.H (2)	72.18 c	132.9 c	205.1 c	141.4 c	217.73 cd	359.1 c
Hand hoeing twice	138.9 b	246.6 b	385.5 b	224.6 b	320.6 b	545.2 b
Untreated check	360.6 a	839.9 a	1200.6 a	613.04 a	896.9 a	2010.0 a
F test	**	**	**	**	**	**

Values having a similar letter, within a comparable group of means, are not significantly different, using revised LSR test at 0.05 levels
H.H: hand hoeing H.H: (2) hand hoeing twice

Table 8. Effect of weed control treatments on number of nodules/plant, fresh and dry weight of nodules in 2013/14 and 2014/15 seasons.

Weed control treatments (L/fed.)	No. of nodules plant^{-1}	Fresh weight of nodules plant^{-1}(g)	Dry weight of nodules plant^{-1}(g)	No. of nodules plant^{-1}	Fresh weight of nodules plant^{-1}(g)	Dry weight of nodules plant^{-1}(g)
	2013/14 season			2014/15 season		
Pendimethalin (1.7 L/fed)	52.6 d	0.8 e	0.5 d	61.5 bcd	0.9 e	0.7 d
Pendimethalin (1.25L/fed) + H.H	59.1 bcd	0.9 de	0.5 d	59.6 cd	1.0 de	1.0 c
Pendimethalin (1L/fed) + H.H (2)	57.3 cd	1.2 c	0.6 c	55.2 d	1.4 c	1.2 b
Butralin (2.5L/fed)	58.8 bcd	1.5 b	0.7 b	61.2 bcd	1.6 b	0.7 d
Butralin (2L/fed) + H.H	53.5 abc	1.7 a	0.9 a	63.9 abc	1.9 a	1.4 a
Butralin (1L/fed) + H.H (2)	53.0 d	1.0 d	0.7 bc	54.7 d	1.1 d	1.2 b
Hand hoeing twice	67.9 a	1.4 b	0.8 ab	70.6 a	1.6 b	1.1 b
Untreated check	64.7 ab	1.5 b	0.8 b	67.2 ab	1.7 b	1.2 b
F. test	**	**	**	**	**	**

Values having a similar letter, within a comparable group of means, are not significantly different, using revised LSR test at 0.05 levels
H.H: hand hoeing H.H (2): hand hoeing twice

3. On vegetative growth characters:

Table 9 showed that growth parameters were significantly affected by weed control treatments with gave the highest number of leaves plant^{-1}, number of branches plant^{-1}, chlorophyll content, leaf area plant^{-1} and plant fresh weight plant^{-1} compared with untreated control treatment in both seasons. The highest values of plant height were obtained by untreated check and pendimethalin at 1.7 L/fed by 49.0 and 43.0 cm, respectively, in 1st season and 52.5 and 46.5 cm, respectively, in 2nd season. Meanwhile, hand hoeing twice treatment gave the highest values of number of leaves plant^{-1} (22.5 and 25.5), %), number of branches plant^{-1} (2.0 and 2.3 cm^2), chlorophyll content (41.0 and 42.5 mg/g), leaf area plant^{-1} (479.4 and 541.6 cm^2) and fresh weight plant^{-1}(97.4 and 102.5g) in both seasons, respectively. Butralin at 2L/fed plus hand hoeing once was the following treatment on increasing values of the previous respective plant characteristics by 20.0& 22.5, 1.8 & 2.0, 40.2 &41.4 , 443.1 & 533.1 cm^2 and 88.1 & 92.8 g in both seasons, respectively.

Table 9. Effect of weed control treatments on pea vegetative growth characters in 2013/14 and 2014/15 seasons.

Weed control treatments (L/fed)	Plant height (cm)	No. of leaves plant^{-1}	No. of branches plant^{-1}	Chlorophyll content SPAD Unit	Leave area plant^{-1} (cm^2)	Plant Fresh weight plant^{-1}(g)	Plant height (cm)	No. of leaves plant^{-1}	No. of branches plant^{-1}	Chlorophyll content SPAD Unit	Leave area plant^{-1} (cm^2)	Plant Fresh weight plant^{-1}(g)
	2013/14 season						2014/15 season					
Pendimethalin (1.7 L/fed)	43.0 b	12.0 e	0.8 e	37.5 cd	360.6g	71.6 e	46.5 b	13.0 f	1.0 f	38.3 cd	405.8 e	74.0 e
Pendimethalin (1.25L/fed) + H.H	41.0 c	16.5 d	1.4 d	38.9 bc	399.5e	77.9 d	43.5 c	17.5 e	1.4 e	39.6 bc	480.0 d	81.9 d
Pendimethalin (1L/fed) + H.H (2)	39.0 d	17.5 cd	1.5 d	39.6 ab	405.7d	79.1 d	41.0 de	19.5 cd	1.5 de	40.4 b	488.2 c	82.5 d
Butralin (2.5L/fed)	41.0c	16.5 d	1.4 d	38.7 bc	393.1f	77.8 d	42.5 cd	18.5 de	1.5 d	39.9 bc	479.0 d	81.4 d
Butralin (2L/fed) + H.H	39.0 d	20.0 b	1.8 b	40.2 ab	443.1b	88.1 b	41.0 de	22.5 a	2.0 b	41.4 ab	533.1 b	92.8 b
Butralin (1L/fed) + H.H (2)	39.0 d	18.5 bc	1.6 c	40.0 ab	418.0c	83.6 c	40.0 e	20.5 c	1.7 c	40.6 ab	492.3 c	87.9 c
Hand hoeing twice	41.0 c	22.5 a	2.0 a	41.0 a	479.4a	97.4 a	43.0 c	25.5 a	2.3 a	42.5 a	541.6 a	102.5a
Untreated check	49.0 a	10.5 e	0.7 f	35.8 d	279.9h	59.2 f	52.5 a	12.0 f	0.8 g	36.7 d	296.5 f	63.7 f
F. test	**	**	**	**	**	**	**	**	**	**	**	**

Values having a similar letter, within a comparable group of means, are not significantly different, using revised LSR test at 0.05 level
H.H: hand hoeing once H.H (2): hand hoeing twice

Application of the previous treatments were effective on controlling weeds and consequently competition was limited and lighter, and water and nutrients were available to promote pea growth compared to other treatments. The effects of the rhizobia on the above mentioned growth traits may be related to the nitrogen fixed which increased nutrition status and the enhancing effects of symbiotic N_2–fixing bacteria on the morphology and/or physiology of the root system which promoted the vegetative growth to go forward. These results are in agreement with those recorded by Abd El-Hamid & El-Metwally (2008).

4. On green pods yield and its components:

Data in Table 10 generally, indicated that all weed control treatments gave highly significant increased on green pods yield and its components. Hand hoeing twice increased on number of green pods plant^{-1} by (66.3 and 65.6%), weight of green pod (g) by (33.0 and 31.1%), number of seeds pod^{-1} by (30.2 and 27.7%), weight of seeds pod^{-1} by (42.1 and 31.1%), total yield of green pods ton/fed by (76.9 and 75.0 %), in both seasons, respectively, as compared with the unweed control. On the other hand, butralin at 2L./fed plus hand hoeing once, produced the highest values of number of green pods plant^{-1} by (62.5 and 32.8%), weight of green pod (g) by (27.8 and 27.6%), number of seeds pod^{-1}by (27.7 and 25.6%), weight of seeds pod^{-1} by (37.1 and 38.1%) and total yield of green pods ton/fed by (72.7 and 70.4%), followed by butralin at 1.0L/fed plus hand hoeing twice, pendimethalin at 1.25L/fed plus hand hoeing once, pendimethalin at 1.L/fed plus hand hoeing twice, pendimethalin at (1.7L/fed) and butralin at 2.5L/fed, respectively, compared with unweed control treatments in both seasons. This result may be due to the effect of the herbicide on the internal growth processes in the plants, reflected in increasing pea yield and its components. Similar results were obtained by Wágner and Nádasy (2006).

Table 10. Effect of weed control treatments on green pods yield and its components of pea plants in 2013/14 and 2014/15 seasons.

Weed control treatments (L/fed)	No. of green pods per plant [1]	Weight of green pod (g)	No. of seeds Per pod	Weight of seeds per pod (g)	Total green pods yield Per plant (g)	Total green pods yield Per fed (ton)	No. of green pods per plant [1]	Weight of green pod (g)	No. Of seeds Per pod	Weight of seeds per pod (g)	Total green pods yield Per plant (g)	Total green pods yield Per fed. (ton)
	2013/14 season						2014/15 season					
Pendimethalin (1.7 L/fed)	8.9f	4.3f	7.4g	2.8e	38.8f	1.3f	9.6f	4.6f	7.9e	4.6f	45.0g	1.5g
Pendimethalin (1.25L/fed) + H.H	9.8de	4.7e	7.8e	3.2d	46.1e	1.6d	10.8d	5.1de	8.2d	5.1de	55.4e	1.9e
Pendimethalin (1L/fed) + H.H (2)	10.0d	4.9d	8.0d	3.4c	49.6d	1.7d	11.2d	5.3cd	8.4c	5.3cd	59.4d	2.0d
Butralin (2.5L/fed)	9.5e	4.6e	7.7f	3.1d	44.5e	1.5e	10.1d	4.9e	8.1d	4.9e	50.4f	1.7f
Butralin (2L/fed) + H.H	12.0b	5.4b	8.3b	3.5b	65.8b	2.2b	13.5b	5.8b	8.6b	5.8b	79.2b	2.7b
Butralin (1L/fed) + H.H (2)	10.7c	5.1c	8.1c	3.4c	45.7c	1.8c	11.7c	5.5c	8.5bc	5.5c	64.6c	2.2c
Hand hoeing twice	13.3a	5.8a	8.6a	3.8a	77.7a	2.6a	15.4a	6.1a	8.8a	6.1a	95.0a	3.2a
Untreated check	4.5g	3.9g	6.0h	2.2f	17.9g	0.6j	5.3g	4.2g	6.4f	4.2g	23.2h	0.8h
F. test	**	**	**	**	**	**	**	**	**	**	**	**

Values having a similar letter, within a comparable group of means, are not significantly different, using revised LSR test at 0.05 level
H.H: hand hoeing once H.H (2): hand hoeing twice

Effect of inoculation with rhizobia and herbicides interaction:

1. On weeds:

Data in Table 11 showed that the effect of interactions between inoculation with rhizobia and weed control treatments on dry weight of grassy, broadleaved and their total weeds (g/m^2) were significant effect at 5% level and suspired in all interactions between uninoculation and weed control treatments in both seasons. The interaction depressed by weight of total weeds categories could be arranged in a descending order as follows: butralin at 2L/fed plus hand hoeing once by 84.8 and 92.1%, butralin at 1.0L/fed plus hand hoeing twice by 84.5 and 81.6%, pendimethalin at 1.25L/fed plus hand hoeing once by 84.3 and 85.8%, pendimethalin at 1.L/fed plus hand hoeing twice by 80.1 and 83.9%, pendimethalin at (1.7L/fed) by 77.5 and 89.3%, butralin at 2.5L/fed by 76.6 and 86.5% hand hoeing twice at 60.0 and 76.9% in two surveys, respectively, in 1st season. Whilst, the controlling percentage on total weeds by the interaction between uninodulation and weed control treatments were 91.4 and 92.8% by butralin 2L/fed plus hand hoeing once, 88.9 and 93.4% by pendimethalin at 1.25L/fed plus hand hoeing once, 87.1 and 85.6% by pendimethalin at 1.7L/fed, 86.1 and 89.3% by pendimethalin at 1.L/fed plus hand hoeing twice,76.2 and 92.4% by butralin at 1.0L/fed plus hand hoeing twice, 85.2 and 86.1% by butralin at 2.5L/fed and 65.0 and 79.9 % by hand hoeing twice, in both surveys, in 2nd season. The same trend and results in first season approximately were observed in the second season.

These results due to rhizobia inocualtion improved the efficacy of herbicidal treatment on controlling weeds. It can be concluded that there is no chance that the herbicides tested in the present study will have any negative effect on the growth of pea rhizobia under field conditions at the concentrations normally used for controlling weeds in peas. (Singh and Wright 1999) were due to effects on the pea plants and not rhizobia. Also, the hoeing operation may play on improving some soil properties i.e, such as soil structure, aeration water penetration and availability of some nutrients to plants. On other world, these results may be due to less competition for nutrients, water and light by limiting weed infestation with two hand hoeing or herbicidal treatments, as results of nutrient uptake.

Table 11. Effect of the interaction between inoculation and some weed control treatments on dry weight of annual broadleaf, grassy and total weeds, 45 and 60 days after sowing during 2013/14 and 2014/15 seasons

	Weed control treatments (L/fed)	Dry weight of weeds (g/m²) at 45 days						Dry weight of weeds (g/m²) at 60 days					
		Grassy weeds	Broadleaf weeds	Total weeds	Grassy weeds	Broadleaved weeds	Total weeds	Grassy weeds	Broadleaf weeds	Total weeds	Grassy weeds	Broadleaf weeds	Total weeds
		2013/14 season			2014/15 season			2013/14 season			2014/15 season		
Inoculation with rhizobia	Pendimethalin (1.7 L/fed)	27.64 efg	17.39 d	45.04 e	17.80 fg	19.23 e	37.03 e	113.6 efg	133.4 efg	246.9 efg	43.26 ef	78.83 d	122.1 de
	Pendimethalin (1.25L/fed) + H.H	14.75 g	16.51 d	31.26 e	2 1.62 fg	15.88 e	37.51e	149.7 efg	175.9 efg	325.6 efg	47.19 ef	35.40 d	82.54 de
	Pendimethalin (1L/fed) + H.H (2)	23.84 efg	14.75 d	38.59 e	23.70 fg	36.84 e	60.55 e	169.8 efg	199.6 ef	369.4 efg	52.19 ef	47.90 d	100.1 de
	Butralin (2.5L/fed)	30.90 e	15.88 d	46.78 e	12.45 fg	14.94 e	27.39 e	143.6 efg	168.7 efg	312.3 efg	21.16 f	19.42 d	40.58e
	Butralin (2L/fed) + H.H	16.06 fg	14.42 d	30.47 e	8.94 g	8.73 e	17.68 e	83.94 g	98.85 g	182.6 g	15.21 f	13.95 d	29.6 e
	Butralin (1L/fed) + H.H (2)	16.85 efg	14.10 d	30.95 e	49.17 efg	27.01 e	76.18 e	206.2 c	259.8 c	466 cd	81.59 def	81.77 d	163.4 de
	Hand hoeing twice	44.74 d	41.38 c	86.12 d	151.19 c	141.4 d	292.6 c	236.9 c	296.0 c	532.9 c	177.4 cde	183.9 cd	361.2 cd
	Untreated check	122.5 a	77.50 c	200.0 b	206.73 b	548.07 c	754.8 b	1060.9 b	1247.1 b	2308.1 b	851.4 b	822.5 bc	1674.0 b
Uninoculation control	Pendimethalin (1.7 L/fe d)	26.26 efg	14.97d	41.23 e	73.79 ef	162.4 cd	236.1 cd	157.6 efg	185.2 efg	342.8 efg	67.91 def	111.8 d	179.7 de
	Pendimethalin (1.25L/fed) + H.H	19.92 efg	15.3 d	35.25 e	19.96 fg	43.84 e	63.81 e	84.09 g	98.84 g	182.9 g	33.94 ef	57.09 d	91.03 de
	Pendimethalin (1L/fed) + H.H (2)	29.79 ef	14.61 d	44.40 e	72.14 efg	158.7 cd	230.9 cd	135.9efg	159.8 efg	295.7 efg	155.9 cdef	172.9 cd	328.9 cd
	Butralin (2.5L/fed)	25.19efg	22.66 d	47.84 e	95.18 de	238.7 c	333.9 c	176.1 d	207.1 e	383.2 e	125.5 def	211.1 cd	336.5 cd
	Butralin (2L/fed) + H.H	14.73 g	12.61d	27.33 e	25.44 f g	39.29 e	64.74 e	91.52 fg	107.6 efg	199.1 g	43.25 ef	72.75 cd	116.0 de
	Butralin (1L/fed) + H.H (2)	53.71c	22.47 b	76.18 c	32.10 fg	90.62 de	122.7 de	96.06 efg	112.9 efg	209.2 efg	201.1 cd	353.7 bc	554.8 bc
	Hand hoeing twice	59.11 c	53.18 b	112.29 c	126.6 cd	351.77 b	478.3 b	254.9 d	299.7 d	554.8 d	271.8 bc	457.3 b	729.1 b
	Untreated check	186.14 b	133.3 a	319.46 a	514.5 a	1131.9 a	1646.4 a	1268.3 a	1490.8 a	2757.0 a	874.7 a	1471.5 a	2346.1 a

Values having a similar letter, within a comparable group of means, are not significantly different, using revised LSR test at 0.05 level
H.H: hand hoeing once H.H (2): hand hoeing twice

2.Bactria nodules

Data in Table 12 show that inoculation of pea seeds with rhizobia and weed control interaction significantly affected number of nodules plant^{-1}, fresh and dry weight of nodules plant^{-1}, compared to these interaction with uninoculated control, in both seasons. Therefore, rhizobia inoculation could be considered as effective biofertilizers which consists of essential components required to cell division, cell elongation and photosynthetic pigments formation due to its enriched in macro– and micro-elements, vitamins and phytohormones (Abdel – Hamid and El – Metwally 2008). The highest increasing values of nodules plant^{-1}, fresh and dry weight of nodules plant^{-1}, was obtained by the interaction between untreated control and rhizobia inoculation by 91.6 & 95.3, 2.0 & 2.1 and 0.99 & 1.58 g, in both seasons respectively. The following interaction were butralin at 2L/fed plus hand hoeing once gave values of nodules/plant^{-1} by 89.3 and 91.2, fresh weight of nodules /plant^{-1} by 2.2 and 2.43g, and dry weight of nodules /plant^{-1} by 1.11 and 1.77g, in both seasons, respectively. The third interaction of increasing values of the previous respective nodules/plant was hand hoeing twice with rhizobia inoculation by 87.8 & 92.9, 1.8 & 2.0 g and 0.91 & 1.46g, in both seasons, respectively. On the other hand, the interactions between all herbicidal treatments and uninoculation had lower values of nodules characrtistics/plant without approximately differences significance expect with the interaction between hand hoeing twice and uninoculation which gave values of nodules/plant by 46.4 & 39.2, fresh weight of nodules/plant by 1.1 & 1.1g and dry weight of nodules/plant by 0.63 & 0.88g, in both seasons, respectively. Similar results were obtained by Noel *et al.* (1996).

Table 12. Effect of the interaction between rhizobia inoculation and weed control treatments on pea numbers, fresh and dry weight of nodules in 2013/14 and 2014/15 seasons.

	Weed control treatments (L/fed.)	No. of nodules plant^{-1}	Fresh weight of nodules plant^{-1}(g)	Dry weight of nodules plant^{-1}(g)	No. of nodules plant^{-1}	Fresh weight of nodules plant^{-1}(g)	Dry weight of nodules plant^{-1}(g)
		2013/14 season			20114/15 season		
Inoculation with rhizobia	Pendimethalin (1.7 L/fed)	81.9c	1.0ef	0.57efg	78.1d	1.15ef	0.84f
	Pendimethalin (1.25L/fed) + H.H	84.5bc	1.1e	0.94bc	87.9bc	1.25e	1.42c
	Pendimethalin (1L/fed) + H.H (2)	74.5d	1.4e	0.52g	85.2c	1.51d	1.10d
	Butralin (2.5L/fed)	84.0bc	1.9bc	0.69d	77.5d	2.07bc	0.91ef
	Butralin (2L/fed) + H.H	89.3ab	2.2a	1.11a	91.3abc	2.43a	1.77a
	Butralin (1L/fed) + H.H (2)	75.1d	1.1ef	0.89g	87.4bc	1.20ef	1.50bc
	Hand hoeing twice	87.8abc	1.8c	0.91bc	92.9ab	2.00c	1.46bc
	Untreated check	91.6a	2.0b	0.99b	95.3a	2.19b	1.58b
Uninoculated control	Pendimethalin (1.7 L/fed)	33.6fg	0.5h	0.41h	31.3g	0.55h	0.40g
	Pendimethalin (1.25L/fed) + H.H	33.8fg	1.1ef	0.53g	35.1fg	1.19ef	0.87f
	Pendimethalin (1L/fed) + H.H (2)	32.8fg	1.0ef	0.54fg	34.1fg	1.18e	0.86f
	Butralin (2.5L/fed)	30.0g	1.0f	0.25i	31.3g	0.89g	0.79f
	Butralin (2L/fed) + H.H	37.7f	1.1ef	0.55fg	48.3e	1.40d	0.87f
	Butralin (1L/fed) + H.H (2)	31.6fg	0.8g	0.50gh	34.9fg	1.06f	0.65g
	Hand hoeing twice	46.4e	1.1ef	0.63def	39.2f	1.10ef	0.88f
	Untreated check	35.1fg	1.3d	0.64de	36.6fg	1.15ef	1.02de

Values having a similar letter, within a comparable group of means, are not significantly different, using revised LSR test at 0.05 level
H.H: hand hoeing once H.H (2): hand hoeing twice

3. On vegetative growth characters:

Data in Table 13 show that inoculation of pea seeds with rhizobia and weed control interaction significantly affected number of leave plant^{-1}, number of branches plant^{-1}, leave area plant^{-1} and plant fresh weight (g) plant^{-1} in both seasons compared to that interaction without inoculation. Therefore, rhizobial inoculation could be considered as effective biofertilizers which consists of

essential components required to cell division, cell elongation and photosynthetic pigments formation due to its enriched in macro– and micro-elements, vitamins and phytohormones (Abdel – Hamid and El – Metwally 2008).

In the other hand, the interaction between inoculation of pea seeds with rhizobia and weed control treatments had a significant increase on number of leaves plant^{-1}, number of branches plant^{-1}, leaf area plant^{-1} and plant fresh weight (g) plant^{-1}, compared to that interaction with uninoculated treatment, except for plant height and chlorophyll content were not significantly effect in both seasons. The interaction between rhizobia inoculation and hand hoeing twice, butralin at 2L/fed plus hand hoeing once, butralin at 1.0L/fed plus hand hoeing twice, pendimethalin at 1.L/fed plus hand hoeing twice, pendimethalin at 1.25L/fed plus hand hoeing once, pendimethalin at (1.7L/fed) and butralin at 2.5L/fed gave the highest values of number of leaves plant^{-1}, number of branches plant^{-1}, leaf area plant^{-1} and plant fresh weight (g), respectively. The interaction between rhizobia inoculation and hand hoeing twice and butralin at 2L/fed plus hand hoeing once gave the highest increasing percentage on the previous receptive growth characteristics by 56.0 & 50.0%, 66.7 & 61.9%, 43.9 & 38.5% and 41.1 & 33.4%, respectively, in first season and 53.6 & 48.0%, 66.7 & 60.9%, 47.7 & 39.8% and 38.8 & 30.9%, respectively, in second seasons. These results are in agreement with those recorded by Abd El-Hamid & El-Metwally (2008) this might have been due to the internal herbicides effect on the plant growth processes. Also, the herbicides tested in this study are known to adversely affect plant photosynthesis. Thus, the decreases observed in the above mentioned traits might be the result directly on reducing photosynthesis.

Table 13. Effect of the interaction between rhizobia inoculation and weed control treatments on pea vegetative growth characters in 2013/14 and 2014/15 seasons.

Weed control treatments (L/fed.)		No. of leaves plant^{-1}	No. of branches plant^{-1}	Leave area plant^{-1} (cm^2)	Plant fresh weight (g) plant^{-1}	No. of leaves plant^{-1}	No. of branches plant^{-1}	Leave area plant^{1} (cm^2)	Plant fresh weight (g) plant^{-1}
		2013/14 season				2014/15 season			
Inoculation with rhizobia	Pendimethalin (1.7 L/fed)	13.0h	1.0g	350.5l	73.1h	14.0ij	1.1hi	456.3h	75.6g
	Pendimethalin (1.25L/fed) + H.H	19.0de	1.6d	408.5f	80.2e	20.0e	1.8d	520.4e	83.0fg
	Pendimethalin (1L/fed) + H.H (2)	20.0cd	1.7d	415.8e	80.5e	22.0cd	1.9d	525.6d	83.5f
	Butralin (2.5L/fed)	19.0de	1.6d	407.0g	80.1e	21.0de	1.8d	519.5d	82.6f-h
	Butralin (2L/fed) + H.H	22.0b	2.1b	470.5b	90.5c	25.0e	2.3b	586.7b	95.3c
	Butralin (1L/fed) + H.H (2)	21.0bc	1.9c	435.2d	85.7d	23.0c	2.0c	543.3c	90.5d
	Hand hoeing twice	25.0a	2.4a	515.3a	102.4a	28.0a	2.7a	597.6a	107.5a
	Untreated check	11.0i	0.8h	289.6m	60.3g	13.0jk	0.9j	312.5l	65.8l
Uninoculated control	Pendimethalin (1.7 L/fed)	11.0i	0.6i	370.8k	70.2i	12.0kl	0.9j	355.4k	72.5k
	Pendimethalin (1.25L/fed) + H.H	14.0gh	1.2f	390.5j	75.7g	15.0hi	1.0ij	439.6j	80.9hi
	Pendimethalin (1L/fed) + H.H (2)	15.0fg	1.3f	395.6h	77.8f	17.0fg	1.1h	450.9i	81.5g-i
	Butralin (2.5L/fed)	14.0gh	1.2f	385.4j	75.6g	16.0gh	1.3g	438.5j	80.3i
	Butralin (2L/fed) + H.H	18.0e	1.5e	415.7e	85.7d	20.0e	1.7e	479.5g	90.3d
	Butralin (1L/fed) + H.H (2)	16.0f	1.4e	400.8g	81.5e	18.0f	1.5f	450.3i	85.4e
	Hand hoeing twice	20.0cd	1.7d	443.5c	92.5b	23.0c	1.9d	485.6f	97.5b
	Untreated check	10.0i	0.6i	270.3h	58.2k	11.0l	0.7k	280.5m	61.7m

Values having a similar letter, within a comparable group of means, are not significantly different, using revised LSR test at 0.05 level
H.H: hand hoeing once H.H (2): hand hoeing twice

4. Green pods yield and its components

The interaction effects between the inoculation with rhizobia and weed control treatments on green pods yield and its components significantly increased number of green pods plant^{-1}, number and weight of seeds pod^{-1} and total green pods yield ton/fed, in both growing seasons Table 14, except for weight of green pod wasn't significantly in the second season. The combination of the inoculation with rhizobia bacteria and hand hoeing twice gave the highest values for all yield traits significantly that may be attributed to the high efficiency of herbicidal treatments on controlling weeds species, beside the benefit bacteria inoculation on pea plants growth in both seasons. The resultant increase on total yield of green pods/fed (ton) may be attributed to the increments on the number of green pods plant^{-1}, number and weight of seeds pod^{-1} and total weight of green ton/fed. Apparently, the promoting effects of inoculation with rhizobia bacteria and hand hoeing twice interaction on growth of pea plants were reflected on increasing total yield and its components. On the other hand, the combination of the inoculation with rhizobia and hand hoeing twice and/or butralin at 2L/fed plus hand hoeing once, which produced the highest values of all yield traits total weight of green pod ton/fed (79.3 &75%), number of green pods plant^{-1} (64.1 & 59.2%), number of seeds pod^{-1}(30 & 26.7%) and weight of seeds pod^{-1} (41.4 & 35.1%), respectively, in 1st season and (72.2 &66.7%); (60.6 & 55.2%); (27.2 & 26.4%) and (25.6 & 23.7%), respectively, in 2nd season , compared to the interaction between untreaded check and rhizobia inoculation. This result may be due to the effect of the herbicide on the weeded treatments may be attributed to their high efficiency in eliminating the weeds (Table 7) and consequently decreasing their competitive ability against crop plants. In other words, these results may be due to less competition for nutrients, water and light by limiting weed infestation with hand hoeing twice or herbicidal treatments, as a result of nutrient uptake or competition between pea plant and weeds weak. These results are in line with those obtained by Bin Ishaq (2002), who reported that the application of biofertilizer increased number and weight of green pods plant^{-1}and total green pods yield as well. Similar conclusion was obtained by El–Waraky *et al.* (2013) on pea.

Table 14. Effect of the interaction between inoculation with rhizobia and weed control treatments on green pods yield and its components of pea plants in 2013/14 and 2014/15 seasons.

	Weed control treatments	No. of green pods per plant [1]	No. of seeds Per pod	Weight of seeds per pod (g)	Total green pods yield (ton) fed	No. of green pods per plant [1]	No. of seeds Per pod	Weight of seeds per pod (g)	Total green pods yield (ton) fed
		2013/14 season				2014/15 season			
Inoculation with rhizobia	Pendimethalin (1.7 L/fed.)	9.3h	7.8g	3.0h	1.5h	10.2g	8.5e	3.3g	1.7j
	Pendimethalin (1.25L/fed.) + H.H	10.0ef	8.3d	3.3e	1.7f	11.0e	8.8d	3.7c	2.0g
	Pendimethalin (1L/fed.) + H.H (2)	10.2e	8.5c	3.7b	1.8e	11.5d	8.9cd	3.8b	2.2f
	Butralin (2.5L/fed.)	9.8fg	8.2e	3.4e	1.6fg	10.6f	8.8d	3.4g	1.9h
	Butralin (2L/fed.) + H.H	12.5b	8.6b	3.7b	2.4b	14.5b	9.1ab	3.8b	3.0b
	Butralin (1L/fed.) + H.H (2)	11.2d	8.5c	3.6c	2.1d	12.8c	9.0bc	3.7c	2.5d
	Hand hoeing thrice	14.2a	9.0a	4.1a	2.9a	16.5a	9.2a	3.9a	3.6a
	Untreated check	5.1j	6.3l	2.4k	0.6k	6.5j	6.7k	2.9j	1.0m
Uninoculated control	Pendimethalin (1.7 L/fed.)	8.5i	7.1k	2.7j	1.1j	9.1i	7.3j	2.8k	1.3l
	Pendimethalin (1.25L/fed.) + H.H	9.6gh	7.4i	3.1g	1.5h	10.7ef	7.7h	3.2h	1.7j
	Pendimethalin (1L/fed.) + H.H (2)	9.8fg	7.5h	3.1g	1.5h	10.9ef	7.9g	3.3g	1.8i
	Butralin (2.5L/fed.)	9.3h	7.3j	2.9i	1.3i	9.7h	7.5i	3.0i	1.5k
	Butralin (2L/fed.) + H.H	11.6c	8.0f	3.4e	2.0d	12.5c	8.1f	3.4f	2.4e
	Butralin (1L/fed.) + H.H (2)	10.2e	7.8g	3.2f	1.6g	10.6f	8.0fg	3.2h	1.8hi
	Hand hoeing thrice	12.5b	8.2e	3.5d	2.3c	14.3b	8.5e	3.6e	2.9c
	Untreated check	3.9k	5.8m	2.1l	0.4l	6.5k	6.1l	2.2l	0.5m

Values having a similar letter, within a comparable group of means, are not significantly different, using revised LSR test at 0.05 level
H.H: hand hoeing once H.H (2): hand hoeing twice

Correlation between characters and green yield:

Data presented in Table 15 indicated that correlation between dry weight of grasses, broadleaf species and peas seed yield was statistically significant and negative at 5% level, and very strong with grassy weeds (-0.84) than with broadleaf weeds (-0.79). Correlation between dry weight of total annual and yield recorded the highest value, where vit negatively affected peas weight of seed / pod by (- 0.82) at 5% level, under combined analysis.

Correlation analysis show that the yield increases due to type of weed competition were positively contributed to the increases in plant height, total green pods yield, number of green pods plant^{-1}, weight of green pod and number of seeds pod^{-1}. The correlation between total weeds and pea weight of seeds pod^{-1}, plant height, total green pods yield and plant fresh weight (g) plant^{-1} were highly statistically significant. Hence, weed control play a major role in increasing pea productivity per unit rhizobia, if applied at the suitable time, rate and stage of weed growth.

Table 15. Correlation coefficient between the studied characteristics and pea yield and its components, combined data of 2013/14 and 2014/15.

Studied characteristics	Broad leaved weeds	Total weeds	Plant Height (cm)	Plant fresh weight (g) plant^{-1}	Total green pods yield /plant	Total green pods yield ton/fed	No. of green pods / plant [1]	Weight of green pod (g)	No. of seeds / pod)	Weight of seeds per pod (g)
Grassy weeds	.959**	.987**	.734**	-.889**	-.836**	-.838**	-.858**	-.765**	-.896**	-.842**
Broadleaved weeds	-	.992**	.769**	-.852**	-.796**	-.797**	-.804**	-.742**	-.871**	-.789**
Total weeds	.	-	.761**	-.877**	-.822**	-.824**	-.836**	-.760**	-.891**	-.821**
Plant height (cm)			-	-.692**	-.644**	-.648**	-.676**	-.569**	-.709**	-.672**
Plant fresh weight (g) plant^{-1}				.866**	.873**	.867**	.876**	.791**	.871**	.867**
Total green pods yield//plant				-	.967**	.974**	.973**	.823**	.939**	.916**
Total green pods yield ton/fed					-	.996**	.990**	.904**	.949**	.940**
No. of green pods / plant [1]						-	.991**	.884**	.947**	.935**
Weight of green pod (g)							-	.885**	.948**	.943**
No. of seeds / pod								-	.916**	.932**
Weight of seeds per pod (g)									-	.963**

Values having a similar letter, within a comparable group of means, are not significantly different, using revised LSR test at 0.05 level

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تـأثيرالتلقيح البكتيـرى بالريزوبيـا ومكافحـة الحشـائش علـى أنـواع الحشـائش ، تكـوين العقـد البكتيريـة وانتاجيـة محصول البسله

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[١] المعمل المركزى لبحوث الحشائش ـ مركز البحوث الزراعية ـ الجيزة ـ مصر.

[٢] قسم بحوث الخضر ـ معهد بحوث البساتين ـ مركز البحوث الزراعية ـ الجيزة ـ مصر.

اعتاد معظم المزارعين في منطقة كفر الشيخ على زراعة محصول البسلة كمحصول خضري نقدي في عروتها بين الموسمين الصيفي والشتوي وأنها بحاجة للمكافحة الحشائش في هذا المحصول. ولذلك تم إجراء هذا البحث لدراسة استجابة نبات البسلة صنف ماستر B والحشائش المصاحبة لها في دراسة حقلية لمدة عامين خلال الموسم الشتوى لعامى ٢٠١٣/٢٠١٤م ، ٢٠١٤/ ٢٠١٥م فى مزرعة محطة بحوث البساتين بسخا محافظة كفر الشيخ. كان التصميم المستخدم هو نظام القطع المنشقة مرة واحدة فى أربع مكررات حيث اشتملت القطع الرئيسية علي نوعين من التلقيح بالريزوبيا وبدون تلقيح بينما القطع الشقية اشتملت على ثماني معاملات لمكافحة الحشائش وهي [مبيد بنديمثالين بمعدل ١,٧ لتر /ف و(مبيد بنديمثالين بمعدل ١,٢٥لتر/ف + عزيق مرة واحدة) و(مبيد بنديمثالين بمعدل١لتر/ف +عزقتين) و(مبيد البيوترالين بمعدل ٢,٥لتر/ف) و(مبيد البيوترالين بمعدل ٢ لتر/ف+ عزقة واحدة) و(مبيد البيوترالين بمعدل١ لتر/ف+ عزقتين) والعزيق مرتين بالاضافه الى بدون معاملة (الكنترول)] . وتتلخص أهم النتائج الرئيسية في هذه الدراسة على النحو التالي: أن تلقيح بذور البسلة بالريزوبيا أدي لزيادة معنوية في كلا الموسمين في أعداد العقد البكتيرية لجذور النبات الواحد والوزن الرطب والجاف للعقد البكتيرية للنبات وزيادة الإنتاجية المحصول طن/ فدان بنسبة (٥٨.١، ٣٧.٥، ٣٧.٥ و ١٦.٧٪)، في موسم الأول و (٥٧.٩، ٣٥.٣، ٣٨.٥ و ٢٢.٧٪)، في موسم الثاني، على التوالي. وأدي هذا الي تحسين خصائص نمو نبات البسلة وأنخفاض عالي المعنوية في الوزن الجاف الكلي للحشائش، وذلك مقارنة بالبذور غير ملقح، وزيادة القدرة التنافسية للنبات البسلة. كما اوضحت أن مبيدات الحشائش المستخدمه لم يكن لها أثرمثبط على تكوين العقد البكتيرية وذلك في أعداد العقد البكتيرية لجذور النبات الواحد والوزن الرطب والجاف للعقد البكتيرية للنبات إلا مع مبيد بنديمثالين بمعدل ١,٧ لتر /ف ، والذي خفض الوزن الرطب والجاف للعقد البكتيرية للنبات بنسبة (٤٧.١ و ٤١.٧٪)، في موسم الأول و(٤٦.٧ و ٣٧.٥٪)، في موسم الثاني. ادت كل معاملات مكافحة الحشائش الي أنخفاض الوزن الجاف للحشائش عريضة و ضيقة الأوراق والحشائش الكلية نظرا لقابلية أنواع الحشائش للمبيدات بالمقارنة بمعاملة بدون معاملة (الكنترول).وكانت أفضل المعاملات لنقص الوزن الجاف الكلي وزيادة المحصول ومكوناته هي معاملة البيوترالين ٢لتر للفدان/عزيق مرة واحدة مقارنة بباقي المعاملات وكانت نسبة زيادة العائد لمحصول البسلة (٧٢.٧ و ٧٦.٩ ٪)، في موسم الأول و(٧٠.٤ و ٧٥.٠٪)، في موسم الثاني. وكان للتفاعل بين التلقيح بالريزوبيا ومعاملات مكافحة الحشائش تأثيرا عالي المعنوية على تكوين بكتريا العقد الجذرية في كلا الموسمين. وكانت معظم معاملات المبيدات الحشائش تحت ظروف عدم التلقيح البكتيري قد أحدثت تثبيطا في عدد ، الوزن الرطب والجاف للعقد البكتيرية / نبات إلا مع بعض المعاملات التي كانت مع التلقيح بالريزوبيا والتي يمكن القول أنها ساعدت في أزالة حدوث الضرر وتحسين واستشفاء للعقد البكتيرية من آثارتثبيط لبعض مبيدات الحشائش. وفي الوقت نفسه، أعطى هذا التفاعل٩٥٪ لمكافحة الحشائش وبالتالي صاحب زيادة في محصول البسلة طن/فدان مع استخدام التلقيح بالريزوبيا وأن معاملة البيوترالين ٢ لترللفدان بالاضافة الي عزيق مرة واحدة أدت لتحسن من أضرار مبيدات الحشائش المحتملة وتحسين صفات النمو البسلة مع التلقيح بالريزوبيا. تم دراسة الارتباط بين الوزن الجاف الكلي للحشائش وأثرت سالبيا علي محصول البسلة وذلك يرجع إلى شدة منافسة الحشائش لمحصول البسلة ومكوناته التي يمكن أن يعزى إلى تحسين مكافحة الحشائش في جانب، وتحسين نمونباتات البسلة وزيادة العقد البكتيرية الفعالة في تثبيت النيتروجين. وهكذا، يمكن أن نوصي المزارعين بتلقيح بذور البسلة بالريزوبيا واستخدام معاملات المبيدات الحشائش المناسبة للسيطرة على الحشائش في الحقل البسله بديل جيد للعزيق اليدوي الميكانيكي.