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Full Length Research Paper

Effects of nitrogen and irrigation interval on broomrape (*Orbanche aegyptiaca*) damage reduction in host plant (*Cucumis sativa* L.)

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In order to study the effects of nitrogen and irrigation interval on broomrape (*Orbanche aegyptiaca*) damage reduction in cucumber (*Cucumis sativa* L.), an experiment with two factors, nitrogen (100, 200 and 300 Kg/ha) and irrigation interval (3, 6 and 9 day), in three replications was performed in the greenhouse of Northern Khorasan Agricultural and Natural Resource Research Center. The results obtained show that the seedling emergence was maximum in the treatment of 200 Kg N/ha. However, plant height and plant number of cucumbers were lower. The number of flowering days was significant under effect of irrigation interval, whereas nitrogen fertilizer did not have a significant influence on this parameter. Hence, increase in irrigation interval caused reduction in the number of flowering days. Maximum length and diameter of cucumber were observed in the highest nitrogen level and minimum irrigation interval or the lowest nitrogen level and medium irrigation interval. The maximum number of cucumbers and weight was obtained in maximum nitrogen and irrigation interval. Increase in irrigation interval caused the number of cucumber to increase and the cucumber weight to decrease. Maximum wet weight of shoot and root were observed in the highest nitrogen treatment. The results also revealed that usage of high and medium nitrogen fertilizer with short time irrigation interval had minimum parasite damage reduction in cucumber yield.

Key words: Broomrape, nitrogen fertilizer, irrigation interval, cucumber.

INTRODUCTION

Damage caused by parasitic weeds on crop yield is not covered (Eizenberg et al., 2005). Parasitic w eeds can damage crop yield up to 100% in high density (Shimi and Benedictus, 1994). Crops that grow in well nutritional conditions have less severe damage. In this situation, host plants produce unlimited yield, but their seeds do not reach full bloom (Edalat, 2002). In the soil with medium fertility, only the host plant reached flowering, and if it does not struggle with the parasite, it gradually weakens and becomes dry.

An *in vitro* study revealed that the direct effects of nitrogen fertilizers on broomrape seed germination and early development confirm that nitrogen in ammonium form is inhibitory than nitrate (Westwood and Foy, 1999). For germinating seeds, exposures to ammonium sulfate for 4 to 8 h (depending on the species) reduced radicle elongation in part, indicating a relatively rapid inhibition. However, all broomrape species were much more sensitive to ammonium toxicity than the host crop species under similar treatment conditions (Westwood and Foy, 1999). A pot experiment conducted under natural

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conditions at Melkasa Agricultural Research Center, Central Ethiopia showed that parasitism occurred mostly in untreated and treated pots with low N fertilizer and manure (Etagegnehu and Suwanketnikom, 2004). Urea at 276 and 207 kg N/ha, ammonium nitrate, ammonium sulfate at 207 kg N/ha and goat manure at 20 and 30 t/ha were found to be most effective in reducing parasitism and enhancing growth of tomato plants.

Growth and development of *O. cumana* and sunflower were quantified under field conditions in Southeastern Romania. Seed yield responded positively to delaying sowing from early April to late May as well as to irrigation and fertilization, and negatively to *O*. *cumana* infestation. Delayed sowing and improved water and nitrogen supply were also associated with increases in parasite number that neutralized yield-boosting effects of irrigation and fertilization at the highest infestation level. Parasites mainly acted as an extra sink for assimilates during sunflower generative growth and impaired host photo-synthesis to a much lesser degree. Results suggest that similar mechanisms govern infection level and host–parasite biomass partitioning across different Orobanche –host systems (Grenz et al., 2008).

A relationship study carried out by Nandula et al. (2000) in order to compare the leaf and root tissues' amino acid profiles of non-parasitized and broomrape-parasitized carrot plants and analyze the amino acid profiles of broomrape at different growth stages showed that individual amino acid concentrations in hydrolysates of leaves of parasitized carrot plants tended to be similar to or greater than those in hydrolysates of nonpara-sitized carrot plants. Roots of parasitized plants tended to have similar or lower amino acid concentrations than roots of non-parasitized plants. The broomrape shoot tended to have lower amino acid concentrations than the tubercle and callus (Nandula et al., 2000). Free amino acid composition of the broomrape tubercle was similar to that of the parasitized root.

Arginine and alanine concentrations in broomrape callus were dramatically higher than those of other amino acids in this tissue or other tissues investigated, and it suggested that changes in the composition of both free and bound amino acids in carrot are associated with broomrape parasitism (Nandula et al., 2000). On the other hand, transpiration in Broomrape is extremely rapid. Hydrostatic pressure on the parasite (1.337 g of water per plant fresh weight per hour) was lower than the pressure on the host plant particularly in scale leaves. It is caused by rapid transpiration and its explanation for flowing of water soluble material to the parasite (Iran and Shahbaziyan, 2005).

Diffusion pressure deficiency (DPD) is high in root parasite, for instance DPD amounts in host plants such as cucumber, tobacco and tomato are 5.04, 4.9 and 10.1 atmospheres respectively and DPD of *O*. *aegyptiaca* parasite is 12.6 atmosphere (Iran and Shahbaziyan, 2005). The uptake of water and metabolites continues as active in all parasites life cycle, but this process considerably in the mid-growth period of root parasites decreased, after which they were removed from the soil (Iran and Shahbaziyan, 2005). An assumption of the hydrothermal time model was found to be invalid since the base temperature for rate of germination also significantly varied with water potential. The relationships of both base temperature and thermal time to water potential were linear such that the germination progress curves in 33 different hydration thermal environments (8 to 26°C and 0 to −1.2 MP) were described according to a new modified thermal time model which accounted for 78% of the variation in the data (Kebreab and Murdoch, 1999).

Many management strategies have been tried against *O. aegyptiaca* and other broomrapes, but few of them have proved reliable and these are only economical in high value agriculture. However, there is no single technology to control *O. aegyptiaca*. Various procedures, such as use of N-fertilizers and dip irrigation, should be carried out to effectively reduce seed bank in soil and its weed stand. Nitrogen really inhibits the growth of weed, and the use of irrigation appears to be a promising culture practice in the management of *O. aegyptiaca* in plants (Cooke, 2002).

Objectives

The objectives of this study are to:

1) Study the broomrape (*O. aegyptiaca*) damage reduction hypothesis, affected by nitrogen and irrigation, in cucumber (*Cucumis sativa* L.) as host plant.
2) Suggest an applicable method to farmers to decrease parasite damage (*O. aegyptiaca*).

MATERIALS AND METHODS

In order to study the effects of nitrogen and irrigation interval on Broomrape (*O. aegyptiaca*) damage reduction in cucumber (*Cucumis sativa* L.), an experiment was performed in three replications with Completely Randomize Design (CRD) in the greenhouse of Northern Khorasan Agricultural and Natural Resource Research Center in 2009 during the study period. The experimental treatments included: nitrogen fertilizer from urea source with three levels (N_1=100, N_2=200 and N_3=300 Kg/ha) and irrigation interval with three levels (I_1=3, I_2=6 and I_3=9 day). A total number of 27 pots, with dimensions of 18 * 25 cm, were prepared for cultivation of cucumber seeds. For filling the pots with soil, the desired soil sampling was carried out and analyzed in soil and water laboratory NKANRRC (Table 1). To improve the desired soil texture, the ratio of 1:1:2 of soil [soil, animal manure (cow) and sand] was mixed. Before filling the pots, soil amendment was prepared with about 600 mg of *Orobanche* seeds (about 120000 seeds) cultivars (*O. aegyptiaca*) that were uniformly infected. Finally, each pot was filled with about 3 kg of soil contaminated seeds. Then the pots were uniformly irrigated for 48 h after the soil pots reached the field capacity limit. Three varieties of cucumber (Royal hybrid) were planted in June 2009 in each pot. Pots were irrigated with net water requirement of cucumber (Alizadeh and Kamali, 2007), and half of the required quantity of urea fertilizer was

Table 1. Agricultural soil characteristics in the study area.

Parameter	Texture	Sand	Silt	Clay (%)	pH	EC dS/m	SP	Lime	Organic matter	N (%)	P	K ppm
Before improvement												
Amount	Clay silt loam	18	52	30	8.24	2.34	55.42	26.75	0.552	0.043	3.15	250
After improvement												
Amount	Sandy loam	56	32	12	7.55	5.22	36.06	36.25	3.63	0.186	110.30	1320

Table 2. Effect of nitrogen levels on some parameters yield components of cucumber.

Experimental treatment	Germination	Plant height (cm)	Mean number of days to flowering	mean length of)cm(cucumber	Mean diameter of cucumber)cm(	Mean of number of cucumber
N_1	2.22 [a]	132.1[a]	49.11[a]	3.70[a]	1.10a	5.22a
N_2	2.00 [a]	95.67[b]	47.56[a]	3.76[a]	0.968a	2.88b
N_3	2.55 [a]	94.11[b]	48.67[a]	4.21[a]	1.15a	5.33a
P_{value}	0.0420	0.0000	0.0446	0.2205	0.0111	0.0000

Experimental treatment	Total cucumber weight (g)	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Shoot/root weight ratio (g)
N1	60.77[b]	58.11[b]	20.42[b]	10.70[a]	5.99[b]	2.915[a]
N2	47.26[c]	61.23[b]	24.48[a]	7.34[b]	8.35[a]	2.569[a]
N3	66.98[a]	69.51[a]	25.27[a]	8.59[b]	9.72[a]	2.788[a]
±Sd	0.0000	0.0001	0.0001	0.0000	0.0000	0.0976

N1 = 100 (Kg/ha), N2 = 200 (Kg/ha), N3 = 300 (Kg/ha).

used as top dressing during cultivation for the experimental treatments. Residual urea required for treatments were used when plants start to flower. In each pot, only one plant survived. Pots were maintained in controlled greenhouse conditions (maximum and minimum average greenhouse temperatures were 41.9 and 10.7°C and average relative humidity was about 60%) until the end of the growth period. Parameters such as plant height, number of days to flowering, mean diameter and height of cucumber, and the total weight of cucumber plants during the growth period were measured and recorded. At the end of the plants' physiological growth stage (102 days after planting), they were harvested from the soil in each pot and fresh weight of shoots and roots of plants were measured. Plants were harvested from the soil surface with their roots separately dried for 48 h in an oven at 72°C and then shoot and root dry weight were recorded. The data were analyzed with statistical software (MSTAT-C) and mean data were compared by Duncan Multiple Test Range in 0.05 confidence level.

RESULTS AND DISCUSSION

Germination of cucumber seeds was not affected by any of the treatments (N, I and their interaction effects), as the planting time was the same and irrigation interval was not performed until full establishment of shrubs (Tables 2 to 4).

Significant difference was observed in the duration of emergence in the treatments, so, plants emerged later and faster in N_3 and N_2 levels respectively (Figure 1). The duration of emergence did not affect irrigation interval (Table 3) because irrigation intervals were not carried out in the full establishment of shrubs. Maximum seed emergence duration was recorded for N_3 and 6 days (Figure 2). However, no significant difference was observed among N_3I_1, N_1I_3 and N_1I_1 treatments (Figure 2).

Maximum plant height was recorded for N_1. It was significantly different from N_2 and N_3, and there was no significant differences between N_2 and N_3 (Table 2). Many plant diseases became severe with high consumption of nitrogen in crops. Using less nitrogen will reduce the effects of such diseases (Rostayee, 2001). Nitrogen fertilizer application time is effective on the occurrence of the disease. *Orobanchaceae* stem compared with the host plant stem almost contain more than three times the nitrogen, seven times the potassium and 22 times the phosphorus. Therefore, parasite dependence increased in the nutrients of host water on a daily basis (Iran and Shahbaziyan, 2005). Three days irrigation interval was responsible for the maximum plant height, while 6 and 9 days irrigation was responsible for minimum plant height (Table 3). Figure 3 shows that maximum plant height treatments were observed in N_1I_1, N_1I_2, N_2I_1 and N_1I_3 respectively, in separate statistical groups from each

Table 3. Effect of irrigation interval levels on some parameters yield components of cucumber.

Experimental treatment	Germination	Duration of emergence	Plant height (cm)	Mean number of days to flowering	Mean length of)cm(cucumber	Mean diameter of)cm(cucumber	Mean of number of cucumber
I_1	2.22 [a]	3.22[a]	120.7[a]	51.00[a]	4.93[a]	1.37[a]	4.22[b]
I_2	2.33 [a]	3.33[a]	102.2[b]	48.67[b]	3.33[b]	0.937[b]	3.77[b]
I_3	2.22 [a]	3.33[a]	99.00[b]	45.67[c]	3.40[b]	0.910[b]	5.44[a]
P value	-	-	0.0000	0.0000	0.0001	0.0000	0.0001

Experimental treatment	Total cucumber weight (g)	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Shoot/Root weight ratio (g)
I_1	71.26[a]	62.52[a]	24.42[a]	11.01[a]	8.58[a]	2.698[a]
I_2	53.82[b]	66.70[a]	24.10[a]	7.92[b]	7.62[a]	2.800[a]
I_3	49.92[b]	59.64[a]	21.66[a]	7.71[b]	7.86[a]	2.774[a]
±Sd	0.0000	0.0123	0.0102	0.0000	0.1166	-

I_1 = day 3, I_2 = day 6, I_3 = day 9.

other. Minimum plant height was obtained from the two treatments, N_2I_2 and N_2I_3, respectively (Figure 3). Plants at 200 kg N/ha, with more emergence speed, had less height than other treatments. Probably, plants of this level were more damaged by parasites as they have longer time duration to the effect of parasite infestation.

Comparison of the mean number of days to flowering did not show any significant differences in N treatments (Table 2), but irrigation interval did. Thus, the 3, 6 and 9 irrigation intervals were responsible for the maximum to minimum number of days to flowering respectively (Table 3). *Orobanche* seeds are susceptible to flooding conditions. Thus, seeds would not be able to germinate, because earth flooding for about one month decreases germination vigor considerably (Rashed Mohasel et al., 2001). In this study, minimum number of days to flowering was also observed in 9 days. The effect of irrigation interval was more effective on nitrogen than on number of days to flowering (Table 4). Maximum average of N_3I_1, N_1I_1 and N_2I_2 was shown as 52.3, 51.0 and 51.0 respectively with non-significant differences among them. Minimum average mean was detected in N_2I_3 and N_3I_2 as 42.0 and 46.3 days mean with significant differences between them (Table 4). Flooding is caused by destruction of the underground vegetative organs of persistent perennial weeds. It is more successful if soil or subterraneous become impermeable. If 15 to 25 cm of water remains in the soil during summer for 3 to 8 weeks, weeds cannot bring their shoot out of water. Thus, adequate water is needed (Rahimiyan et al., 1990). However, flooding method cannot control all vegetative organs of weeds, because the vegetative buds of these organs go to sleep and may be tolerant to adverse conditions. Even a short period of flooding for 3 to 8 weeks cannot be expected to destroy the seeds of weeds if they are yet to germinate (Rahimiyan et al., 1990).

Mean length of cucumber and diameter did not show any significant difference with each other in N treatments (Table 2), but 300 Kg N/ha did and it had the most significant difference. These two parameters had the maximum plant height in less irrigation interval with 4.9 cm length and 1.4 cm diameter, and significant difference with other irrigation intervals (Table 3). Maximum length of cucumber was observed in N_2I_1, N_3I_1 and N_1I_2 with 5.5, 5.4 and 4.7, and non-significant difference was observed among them respectively (Figure 4). Minimum length of cucumber was shown in N_2I_2, N_1I_3 and N_3I_3 treatments respectively (Figure 4). Mean diameter of cucumber was similar to mean length (Table 4). So, their maximummean under interaction effect was detected in high N level and minimum I, or in low N level with medium I. Although *Orobanche* damage was severe in low fertile soil, poultry manure or fertilizers, especially nitrogen, have positive effect in reducing *Orobanchaceae* damage. It has been reported that nitrogen can directly influence *Orobanche* seed germination and not through effects on the host (Mousavi and Shimi, 2008).

Table 4. Effect of nitrogen and irrigation interval levels on some parameters yield components of cucumber.

Exp. treatment	Germination	Mean number of Days to Flowering	Mean length of)cm(cucumber	Mean diameter of)cm(cucumber	Mean of number of cucumber	Total cucumber weight (g)	Shoot fresh weight (g)	Root dry weight (g)	Shoot/Root Weight Ratio (g)
N_1I_1	2.33 a	51.00 ab	3.88 bc	1.11 b	5.33 b	61.90 c	59.88 cd	2.32 d	3.525 a
N_1I_2	2.33 a	48.67 cd	4.71 ab	1.49 a	5.33 b	85.07 a	66.85 bc	9.75 b	2.545 cde
N_1I_3	2.00 a	47.67 cde	2.50 de	0.712 d	5.00 b	35.35 e	47.60 e	5.89 c	2.674 bcde
N_2I_1	2.00 a	49.67 bc	5.51 a	1.43 a	2.66 c	69.39 b	66.35 bc	12.02 a	2.205 e
N_2I_2	2.00 a	51.00 ab	1.55 e	0.358 e	3.33 c	16.79 f	57.96 d	3.55 b	2.998 abc
N_2I_3	2.00 a	42.00 f	4.21 bc	1.10 bc	2.66 c	55.60 d	59.37 cd	9.50 a	2.504 cde
N_3I_1	2.33 a	52.33 a	5.39 a	1.57 a	4.66 b	82.49 a	61.32 cd	11.41 b	2.364 de
N_3I_2	2.66 a	46.33 e	3.75 bc	0.961bc	2.66 c	59.61 cd	75.28 a	9.57 b	2.856 bcd
N_3I_3	2.66 a	47.33 de	3.50 cd	0.910cd	8.66 a	58.82 cd	71.94 ab	8.20 b	3.144 ab
P_{value}	-	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0005

N1 = 100 (Kg/ha), N2 = 200 (Kg/ha), N3 = 300 (Kg/ha), I_1 = day 3, I_2 = day 6, I_3 = day 9.

The researchers estimated the damage caused by parasite *Orobanche* (*O. aegyptiaca*) economically to potato product (*Solanum tuberosum*) as sprinkler irrigation is used in Hamedan province (Iran). In farms that have delayed planting, sprinkler irrigation could be used to reduce *Orobanche* damage up to 11.7% than surface irrigation. The high consumption of poultry manure (more than 6 t/h) decreased the damage caused by *Orobanche* by 2.9% compared to farms that had not received any poultry manure (Jahedi and Jafari, 2005).

Maximum mean number of cucumber was shown in N_3 and N_1. It was lower in N_2 than the two other levels with significant difference (Table 2). Maximum mean number of cucumber was exhibited in 9 days with 5.4 mean and significant differences with I_2 and I_1 (Table 3). Mean number of cucumber was in three statistical groups under effect of N and I (Table 4). Maximum mean number of cucumber (8.6) was observed in N_3I_3 and (a) statistical group, with significant difference among other treatments (Table 4). N_1I_1, N_1I_2, N_1I_3 and N_3I_1 with 5.3, 5.3, 5.0 and 4.6 mean respectively were in (b) statistical group. Comparison of the remaining treatments showed that all of them had minimum mean number of cucumber and were in the (c) statistical group with non-significant difference (Table 4). Comparison of cucumber mean number result under effect of N and I showed that number of cucumber increased minimum N with each I level. Six days I under effect of all N levels caused the comparison between minimum number of cucumber and other treatments.

A study of total cucumber weight showed that N_3, N_1 and N_2 levels with 67.0, 60.7 and 47.2 g respectively had maximum to minimum weight (Table 2). Some nutrients can affect the occurrence of disease indirectly through a change in soil pH. Nitrogen source can be selected as host, while the pathogenic factors can be removed and prevented via changing of the soil pH (Rostayee, 2001). Ammonia nitrogen form generally causes lower pH, while the nitrate form of nitrogen increases pH (Rostayee, 2001).

However, the making conditions of nitrogen fertilizer for fungal diseases on parasite reduce *Orobanche* damage (Mousavi, 2001). One of those mushrooms that grow on *Orobanche* and whose activities prevent *Orobanche* damage is Fusarium (*Fusarium oxysporum*) (Ershad, 2009; Mehrabi Koshki, 1997). Ammonia made of urea causes low soil pH around the root and thus it makes favorable conditions for the activity of Fusarium fungus and *Orobanchaceae* damage (Mehrabi, 1997). *F. oxysporum* strains cause decomposition in some *Orobanchaceae* family plants flowers. Thus, it makes the flower stems and nodes of *O. aegyptiaca*, *O. ramose* and *O. mutely* to become rotten. The mentioned plants are parasitic of tobacco, tomato and cabbage. Fungi do not attack host plants. Also, *F. oxysporum* cause root rot in *Orobanchaceae* crops but do not attack crops (Iran and Shahbaziyan, 2005). Its yield was 6.5 t/ha for *Orobanchaceae* at infected melon farms. Fungi usage increased yield to 34.3 t/ha, as a result, dry matter and total sugar content of melon also

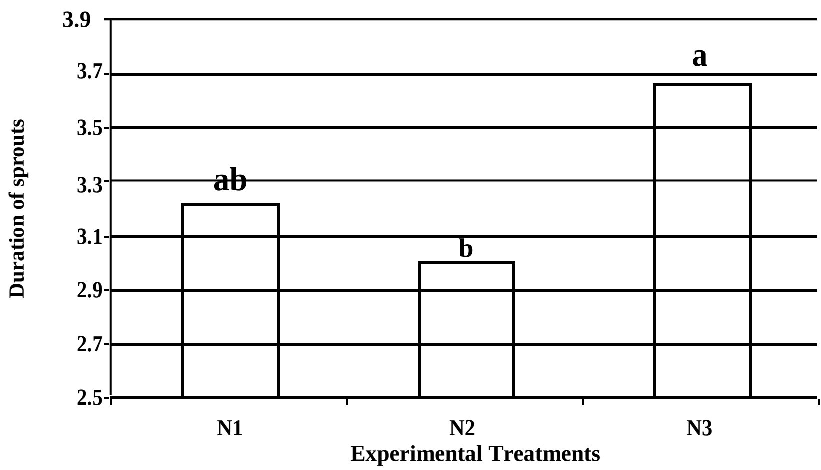

Figure 1. Effect of nitrogen levels (100,200 and 300 Kg/ha) on duration of emergence.

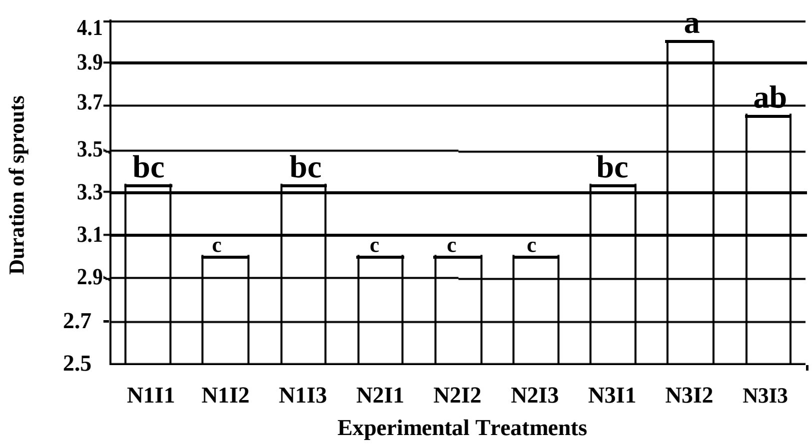

Figure 2. Effect of nitrogen levels (100, 200 and 300 Kg/ha) and irrigation interval (3, 6 and 9 day) on duration of emergence.

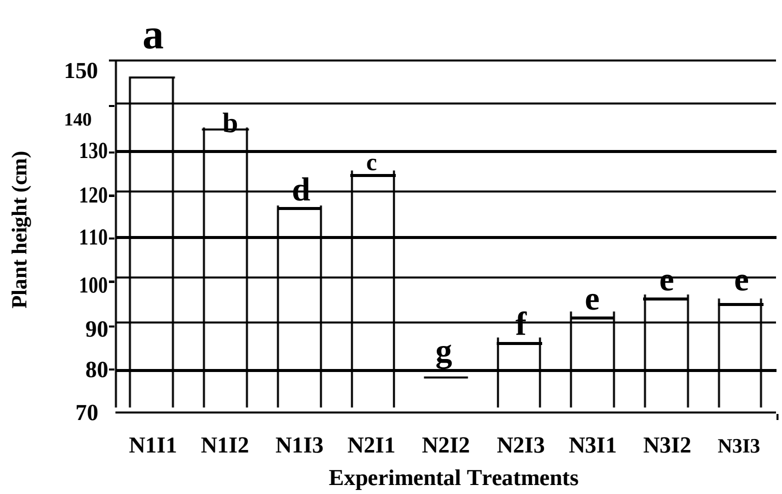

Figure 3. Effect of nitrogen levels (100,200 and 300 Kg/ha) and irrigation interval (3, 6 and 9 day) on plant height (cm).

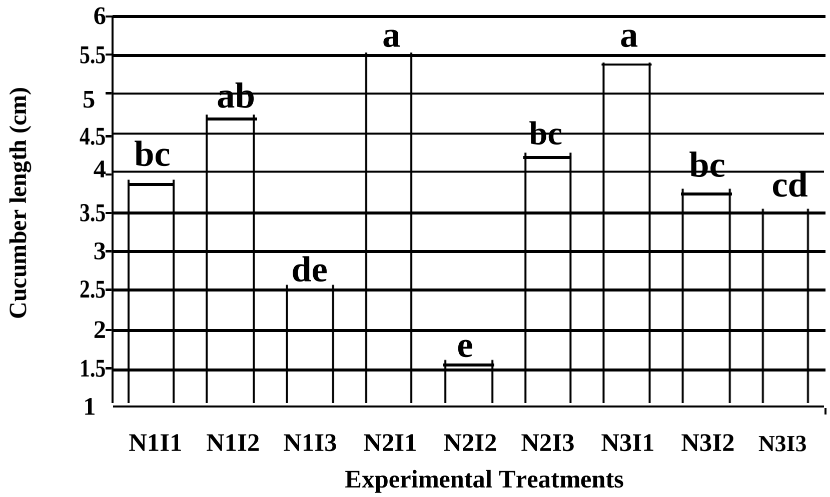

Figure 4. Effect of nitrogen levels (100, 200 and 300 Kg/ha) and irrigation interval (3, 6 and 9 day) on cucumber length (cm).

improved (Iran and Shahbaziyan, 2005).

Three days irrigation interval with 71.2 g showed weight with significant difference, whereas 6 and 9 days irrigation interval with 53.8 and 49.9 g were observed in the same statistical group (b) with non-significant difference (Table 3). Maximum total cucumber weight was observed in N_1I_2 and N_3I_1 as 85.07 and 82.5 g in the same statistical group, while the minimum of it was observed in N_2I_2 and N_1I_3 with significant difference and having 16.8 and 35.5 g weight respectively (Table 4). Comparison of the results obtained for the number of cucumber and cucumber weight under effect of N levels showed that the maximum number of cucumber and cucumber weight were in $N_3>N_1>N_2$. Comparison of the results obtained for the number of cucumber and cucumber weight under effect of I was also observed in $I_3>I_1>I_2$ for number of cucumber and $I_1>I_2>I_3$ for cucumber weight. The results showed that the number of cucumber increased with increase in irrigation interval, but cucumber weight decreased. A study on the effect of sowing date on *Striga hermonthica* infestation of maize and sorghum indicated a linear relationship (Gbèhounou et al., 2004). When sowing was delayed for 30 days, crops were 3.5 to 5 times less infested than after early sowing, which may be caused by a combined effect of a dying-off process of the seeds and excess soil moisture (Gbèhounou et al., 2004). Although measurements of soil moisture content did not show measurable differences in the course of the rainy season, it may be assumed that this resulted in leaching of host root exudates following heavy showers, which reduced *Striga* germination (Gbèhounou et al., 2004).

Maximum shoot fresh weight was observed in N_3 levels with significant difference with other levels (Table 2). Shoot fresh weight levels had no significant difference in any of the treatments under effect of I (P≤0.05) (Table 3). Maximum shoot fresh weight was acquired in N_3I_2, N_3I_3, N_1I_2 and N_2I_1 with 75.3, 71.9, 66.8 and 66.3 g weight respectively, while minimum shoot fresh weight was observed with significant difference in N_1I_3 and N_2I_2 with 47.6 and 57.9 g (Figure 5). Study of the effect of nitrogen applied as ammonium nitrate at 0, 20, 40, 60, 80 and 100 ppm (wt per vol) in either distilled H_2O or modified Hoagland's solution on germination and radicle length of branched broomrape in association with growing seedlings of different crops indicated that as nitrogen rate increased, seed germination and radicle length of branched broomrape decreased linearly in flax, lentil, pepper, tomato and wheat in modified Hoagland's solution (Abu-Irmaileh, 1994). The parasite's seed germination was considerably lower in the media with wheat than with other crops, and lower still in the absence of crop seedlings (Abu-Irmaileh, 1994).

Minimum root fresh weight was shown in N_1 with significant difference with two other levels (Table 2). The trend in root fresh weight was similar to that in shoot fresh weight under effect of irrigation intervals. So, none of the treatments did show significant difference with each other (Table 2), but the maximum root fresh weight was detected in minimum irrigation interval level. Maximum root fresh weight under effect of interaction was also observed in N_2I_1 and N_3I_2 with different statistical groups (Figure 6). Minimum root fresh weight was also shown in N_1I_1, N_1I_3 and N_2I_2 (Figure 6). The influence of various nutrients on parasitism of tomato plants by Egyptian broomrape and on stimulation of broomrape seed germination by strigol analogs was investigated in greenhouse and laboratory experiments (Jain and Foy, 1992). Parasitism occurred most readily in potting media having low fertility. Addition of nitrogenous compounds to potting media resulted in inhibition of broomrape parasitism. Ammonium nitrate with potassium

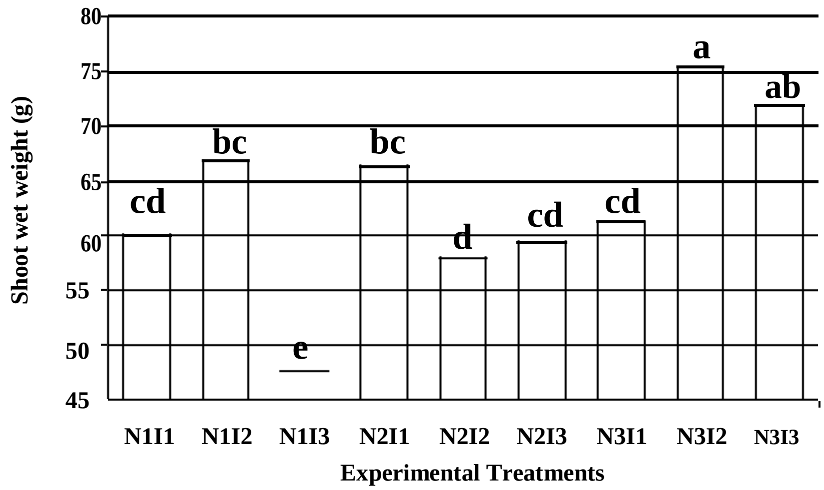

Figure 5. Effect of nitrogen levels (100, 200 and 300 Kg/ha) and irrigation interval (3, 6 and 9 day) on shoot fresh weight (g).

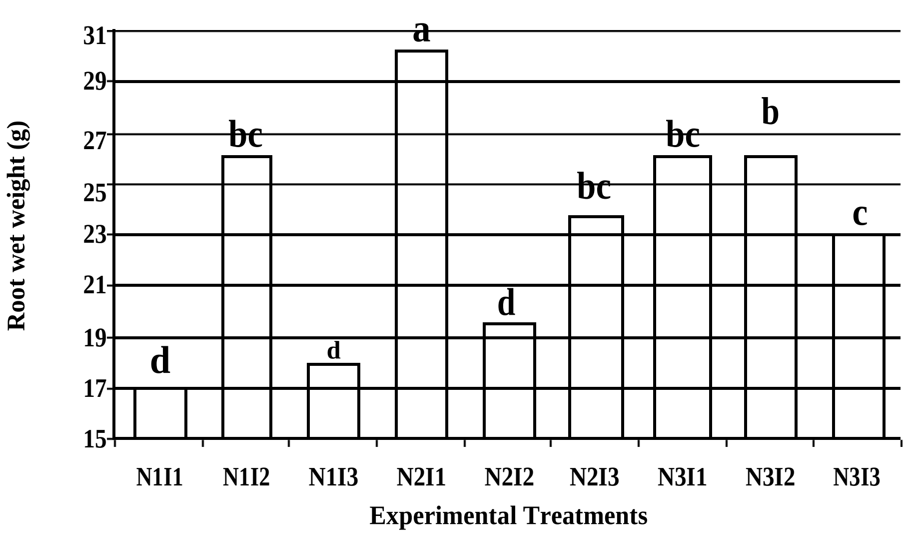

Figure 6. Effect of nitrogen levels (100, 200 and 300 Kg/ha) and irrigation interval (3, 6 and 9 day) on root fresh weight (g)

phosphate or ammonium phosphate alone was most effective in reducing parasitism and enhancing growth of tomato plants (Jain and Foy, 1992). In the laboratory, GR 24 (5 μM) induced higher germination in seeds preconditioned in 10 mM ammonium nitrate, with or without potassium phosphate, compared with seeds preconditioned in sodium chloride. Preconditioning of seeds in sodium nitrate (10 mM) and treatment of seeds with GR 24 stimulated germination, whereas, preconditioning of seeds in ammonium salts (1 mM ammonium sulfate or 10 mM urea) and treatment of seeds with GR 24 inhibited germination significantly (Jain and Foy, 1992).

Comparison of shoot dry weight under effect of N fertilizer (Table 2) showed that the maximum shoot dry weight was observed in N_1 level with significant difference in other levels. Comparison of shoot dry weight and shoot fresh weight showed that water percent in 300 Kg N/ha was at its maximum in shoot fresh weight, while water percent in 100 Kg N/ha was at its maximum in shoot dry weight. Application of more nitrogen causes new vegetative growth, plant watery and plant maturity delay (Rostayee, 2001).

Estryga is a weed found in low fertility soils and its emergence is less in fertile soils. Tolerance of *Estryga* is low in nitrate uptake. This weed only needs a little concentration of nitrate as its essential nutrient because more concentration is toxic for it. 200 mg/L of urea and more amount of it dramatically prevent parasite germination and increase radicle length, while 400 mg/L of urea decreased germination rate and this reduction was 18 and 23% in the relatively acidic and alkaline conditions, respectively (germination percent was 77 to 88% without urea). Radicle length is only 0.2 mm in the presence of urea, while root length is 2.3 mm in the absence of it (Iran and Shahbaziyan, 2005). Maximum shoot dry weight was observed in 3 days with significant difference in 6 and 9 days, but shoot drying under effect of irrigation interval caused maximum dry weight change among treatments compared to shoot fresh weight (I_2 to I_1) (Table 3). Shoot dry weight under effect of N and I was shown to be 14.5, 10.6, 10.3 and 8.8 g in N_1I_1, N_1I_2, N_2I_1 and N_3I_2 respectively with significant difference among them (Table 4). Minimum shoot dry weight was also observed as 4.3 and 6.9 g with significant difference among each other in N_2I_2 and N_1I_3 (Table 4). Jordanian farmers generally observed that the increase in animal manure against soil infection with *Orobanchaceae* reduced infection in their farms (Abu-Irmaileh, 1979). *Estryga* contamination and the amount of stem damage were studied in sorghum field at different nitrogen levels (12.5 and 25 mg N per kg soil) (Horvath, 1987). Sorghum root secretion considerably increased from zero milligrams of N per liter to 30 mg N per liter and the stimulation induced in the 150 mg N/L could not cause germination of *Estryga*. Some percentage of nitrogen (as urea, 100 kg ha) did not work significantly on *Estryga* number, but its maturity can be fastened, total Panykl increased and yield also increased to about 77% (Horvath, 1987).

Minimum root dry weight was observed as 6.0 g with significant difference in N_1 (Table 2). The trend in this parameter was similar to that of root fresh weight under the effect of N. Root dry weight did not show any significant difference in any of the treatments under effect of irrigation intervals (Table 3). Maximum root dry weight was observed in N_2I_1 and N_2I_3 with no significant difference between the parameters, whereas minimum root dry weight with 2.3 and 5.9 g weight was shown in N_1I_1 and N_1I_3 respectively with significant difference between the parameters (Table 4). Field and greenhouse studies were conducted in Lebanon to investigate the effect of elementary sulphur (0, 1, 4, 8, and 12 t/ha) with or without chicken manure (20 t/ha) on *Orobanche ramosa* growth and development in eggplant and potato (Haidar and Sidahmed, 2006). Sulphur alone was ineffective in reducing *Orobanche* growth and infestation or increasing the yield of either eggplant or potato. For both crops, chicken manure alone or with sulphur at all tested rates was effective in reducing *Orobanche* growth and infestation early in the season in comparison with the control. Unlike potato, the mixtures of chicken manure and sulphur at 8 and 12 t/ha significantly reduced *Orobanche* infestation later in the season (75 and 90 days after transplanting) in eggplant. However, the mixtures of chicken manure and sulphur at all tested rates significantly reduced the dry weight of *Orobanche* and increased eggplant and potato yield when compared with the control (Haidar and Sidahmed, 2006).

Comparison of treatments under effect of nitrogen and irrigation interval separately demonstrated that shoot/root weight ratio did not show any significant difference (Tables 2 and 3), but the maximum shoot/root weight ratio was observed under effect of nitrogen in $N_1 > N_3 > N_2$ and $I_2 > I_3 > I_1$ for irrigation interval, indicating that shoot/root ratio was high at 100 kg of N/ha and 6 days irrigation. An immeasurable amount of damage was caused by angiosperms parasites, such as loss of water and nutrients and the reduction of their transportation to the uninfected shoot host which could be the cause of the relatively withering or temporal death of these sections. The parasites forcefully absorb organic metabolites that are transported to the organs. Concentration of the cell sap in the host plant is less than that of *Orobanche* in suction organs. Diffusion pressure deficit (DPD) in the suction organs parasite is always greater than DPD in the host plant roots. Parasites in plant make possible the intake of nutrients from the host because of their higher osmotic pressure (OP) (Iran and Shahbaziyan, 2005). Maximum shoot/root ratio was observed in N_1I_1, N_3I_3, and N_2I_2 with significant difference (Table 4). Minimum of this ratio was also shown in N_2I_1 with significant difference amid other treatments. Plants with low root biomass were less infected by parasite. Comparing *Aquadalce* bean cultivar with resistant cultivar *Giza402*, it was observed that they both have significantly higher root biomass. In transverse sections of these two varieties of root vascular system, several differences were observed at the time of flower bud formation and flowering stage. As such, *Giza402* had a thicker cortex layer, and late flowering which simulated delay of *O. crenata* germination (Gil et al., 1987).

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