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Effect of Nitrogen Fertilizers on Branched Broomrape (*Orobanche ramosa* L.) in Tomato (*Lycopersicon esculentum* Mill.)

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ABSTRACT

A pot experiment was conducted under natural conditions at Melkasa Agricultural Research Center, Central Ethiopia to study the effects of various levels of nitrogen, applied as ammonium nitrate (NH_4NO_3), ammonium sulfate $(NH_4)_2SO_4$, urea (NH_2CONH_2), chicken, cow, and goat manure on branched broomrape (*Orobanche ramosa* L.). Parasitism occurred most in untreated and treated pots with low N fertilizer and manure. Urea at 276 and 207 kg N/ha, ammonium nitrate, and ammonium sulfate at 207 kg N/ha and the goat manure at 20 and 30 t/ha were found to be most effective in reducing parasitism and enhancing growth of tomato plants. Even though drastic reduction of branched broomrape infestation was obtained, ammonium nitrate and ammonium sulfate at 276 kg N/ha seemed to be injurious to tomato plants. As nitrogen rates increased, the numbers and dry weights of shoot of branched broomrape decreased and the yields of tomato increased linearly except the yields obtained from the highest rate of ammonium nitrate and ammonium sulfate. This result indicated that branched broomrape infestation of tomato decreased with increases of soil nitrogen.

Key words: branched broomrape, tomato, animal manure, nitrogen fertilizer, parasitic weeds

INTRODUCTION

The branched broomrape is an obligate root parasite of many economically important dicotyledonous crops such as tomato (Figure 1), tobacco, potato, cabbage, eggplant, carrot, mustard, and sunflower. Its area of distribution is predominantly in the Middle East, Eastern Europe, the Mediterranean basin, Western Asia, East Africa and America (Pieterse, 1979; Jain and Foy, 1989; Parker and Riches, 1993; Press and Grave, 1995; Yokota *et al*., 1998; Yoneyama *et al*., 2001).

Among the four species of the genus *Orobanche* occurring in Ethiopia *Orobanche ramosa* L. is the most prevalent and devastating in the central rift valley, where the main vegetable crops are grown in the country. It mainly threats tomato production. Many tomato fields are abandoned and replaced by other crops in the area (Ahmed and Mohammed, 1992; Parker, 1992; Beyenesh and Geberemariam, 1994). Ecologically, branched broomrape is found in open, sunny habitats that would favour increased transpiration (Musselman, 1980).

The seeds of this parasitic weed are dark brown oval and tiny, measuring approximately 0.2 by 0.3 mm. They are known to remain viable in the soil for up to 20 years. In order to germinate, broomrape seeds require a period of preconditoning and the presence of a germination stimulant, a chemical signal exuded by a host (or non-host). In the total-host relationship, two phases must be

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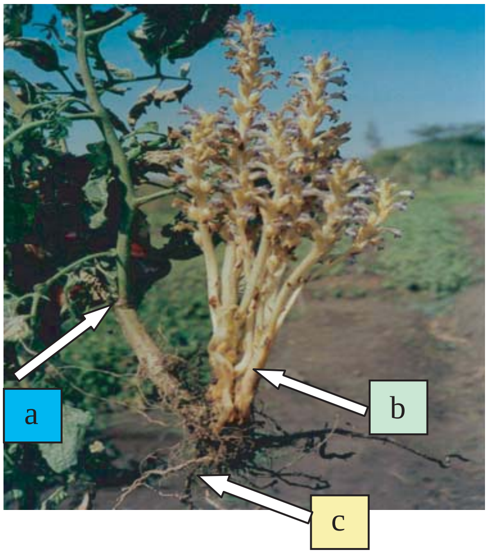

Figure 1 Branched broomrape attached with tomato roots a: tomato plant; b: branched broomrape; c: root attachment.

recognized. In the first phase, the host root stimulates the seed to germinate and induces it to produce an independent seedling; in the second phase, the seedling becomes attached to the root of the host and thereafter exists parasitically upon it. The restriction of host species refers in many instances to the second phases; the first stimulation can be probably given by the roots, which are never parasitized (Musselman, 1980; Jain and Foy 1989; Westwood and Foy, 1999; Joel, 2000; Morozov *et al*., 2000).

Like all members of the family which totally lack of chlorophyll hence it lacks the ability to synthesize its own food. It severely reduces crop yield by drawing carbon, nutrients, and water through haustoria that connect the parasite to the host's vascular system. Severe infestations of tomato field by this parasite seriously reduce yield and can lead to total crop failure, especially if plants are infested during their early stages of development (Kasrawi and Abu-Irmaileh, 1989; Nandula *et al*., 1996; Westwood and Foy, 1999; Morozov *et al*., 2000). Hand pulling is used widely to control branched broomrape but it is inefficient because damage from the parasite normally occurs prior to broomrape emergence. It is also injurious to tomato plants (Abu-Irmaileh, 1979; Parker and Wilson, 1986; Thahabi, 1994). Options for branched broomrape control are limited for most crops because of lack of mechanical control and reliable, selective herbicides. Various alternative control strategies have been tested, and one that has received considerable attention is the use of nitrogen fertilizers. High nitrogen application reduces development of *O. aegyptica* Pers. and *O. crenata* Forsk. Similarly, nitrogen reduces *O. ramosa* L. infestation on tomato and tobacco and reduces *O. crenata* infestation on faba beans.

Ghosheh *et al*. (1999) suggested a possible use of olive jift as an inexpensive organic material for branched broomrape control. Farmers in Jordan have commonly observed that the addition of manure to soil reduced the infestation of broomrape in their fields (Abu- Irmaileh, 1979). Few farmers in Ethiopia suggested that the goat manure showed effective control of *Orobanche* spp. Hence, this experiment was initiated to investigate the influence of nitrogen fertilizers and animal manures on branched broomrape (*Orobanche ramosa* L.) and tomato (*Lycopersicon esculentum* Mill.).

MATERIALS AND METHODS

A pot experiment was carried out under natural conditions at Melkasa Agricultural Research Center, Central Ethiopia. Randomized complete block designs with four replications were used. Three inorganic fertilizers, each at four rates were used as treatments in experiment I, whereas three organic fertilizers (manure), each at three rates were used in experiment II.

Branched broomrape seeds were collected from Nura Era state farm tomato fields. Soil and sand were sterilized in oven at 105°C for 24 hours before planting. The organic matter content and chemical composition of the soil and manure were analyzed before planting (Table 1 and 2). Plastic

Table 1 Organic matter content and chemical composition of the soil used in the potting media.

Texture (%)			Texture	pH	EC	CEC	OM	Total N	P
Sand	Silt	Clay	class	1:2.5	1:2.5		(%)	(%)	(ppm)
57.3	94	11.3	Sandy loam	7.8	0.449	55.25	1.96	0.097	14.96

Table 2 Analysis of animal manure after decomposed for 7 years and stored under shading condition.

Type of manure	PH	OM (%)	Total N (%)	P (ppm)
Chicken	6.53	21.08	1.82	237.13
Cow	7.68	21.93	1.89	83.33
Goat	8.15	31.32	2.7	150.50

pots (22 cm diameter) of 18 cm in height with holes at the bottom were filled with soil mix (3 soil: 1 sand), 4 kg per pot. Composted manure for 7 years also mixed with the soil mix and filled the pots. The soil was sandy loam, with pH of 7.8 and electrical conductivity of 0.449 (Table 1). Tomato seeds were planted in the seedling trays (30 cm^3 / cell). The variety of tomato used was Roma VFN. A hundred mg of branched broomrape seeds were mixed with 200 g sand and thoroughly mixed with 600 g soil mixed by passing through a plastic funnel five times in each case and added to the upper 2 cm of the pots. The pots were irrigated with 200 ml of tap water every day for three weeks in preconditioning. Five weeks-old tomato seedlings (at four leaves stage) were transplanted into plastic pots (one plant/pot). Recommended rate of phosphurous (92 kg P/ha) for tomato was applied as blanket application on all pots treated with inorganic fertilizers including controls. Triple super phosphate (TSP) and urea were used as source of P and N, respectively. All N sources of inorganic fertilizers were splitted in to three and applied at 15 days after transplanting, at flowering and at fruiting stages. These fertilizers were applied on moist soil by spreading on the soil surface and irrigating immediately. Emerged branched broomrape flower shoots were counted every week. The average air temperature and rainfall over the growing period were 23°C and 59 mm respectively.

At the end of the experiment (four months after transplanting), the soil was washed carefully from the roots, and the heights and fresh weights of tomato shoot and root were taken from each pot. Tomato shoots and roots, branched broomrape shoots were dried in the oven at 70°C for 48 hours. Number, dry weight of branched broomrape flower shoot, fruit number, yield, tomato shoot height and root length, tomato shoot and root dry weight were taken as parameters (Ahmed and Parker, 1986; Jain and Foy, 1992). The data were subjected to analysis of variance and the means were separated by Duncan's multiple range test at 5% level of significance.

RESULTS AND DISCUSSION

Effects of nitrogen fertilizer on the parasitism of tomato plant by branched broomrape

Parasitism occurred mostly in pots, untreated and treated, with low N- fertilizer. Urea at 276 kg N/ha and ammonium nitrate at 207 kg N/ha were the most effective in reducing parasitism and enhancing growth of tomato plants. The application of ammonium nitrate and ammonium sulfate at 276 kg N/ha caused reduction in branched broomrape but they were injurious to tomato plants. Similar results were obtained by Abu-Irmaileh (1981), who reported that the higher rates of NH_4NO_3 and $(NH_4)_2SO_4$ were injurious to tomato and tobacco plants.

The average number of branched broomrape attachment on tomato plants in the non-fertilized pots was 21 (Table 3). The high numbers of branched broomrape also occurred in pots treated with lower rates (69 kg N/ha) of ammonium nitrate, ammonium sulfate and urea with average numbers of branched broomrape attachment on tomato plants were 13, 16 and 15 respectively. The average number of branched broomrape in pots with high fertility was 3-5. Mean shoot dry weight of branched broomrape per tomato plant in untreated pot was high as 5.5 g, whereas mean of shoot dry weight of branched broomrape per tomato plant was 0.6-1.35 g in well fertilized pots. The growth of tomato plants, in untreated and treated with lower rates of nitrogen was considerably poorer than that of tomato plants treated with higher rates.

The average shoot height and dry weight, average root length and dry weight, and yield were 38 cm, 16 gm, 25 cm, 3 gm and 147 g respectively in untreated pots. This reduction in growth of tomato plant was partly related to the numbers of broomrape parasite attached to each tomato plant. In general, the maximum reduction in branched broomrape parasitism occurred in pots fertilized with ammonium nitrate, ammonium sulfate and urea at 276 and 207 kg N/ha. The highest rates of ammonium nitrate and ammonium sulfate could not be acceptable due to a severe injury to tomato plants. There was no significant difference of parasitism between pots treated with urea at 207 and 276 kg N/ha, ammonium nitrate at 207 and 276 kg N/ha and ammonium sulfate at 207 and 276 kg N/ha. Hence ammonium nitrate, ammonium sulfate and urea at 207 kg N/ha were the optimum levels in controlling branched broomrape.

Abu-Irmaileh (1981) reported that ammonium nitrate and ammonium sulfate reduced the biomass of branched broomrape on tomato and tobacco grown in pots. Ammonium nitrate with potassium phosphate or ammonium phosphate alone was the most effective in reducing *O. aegyptiaca* parasitism by enhancing growth of tomato plants (Jain and Foy, 1992). Westwood and Foy (1999) confirmed that nitrogen in the ammonium form was more inhibitory than nitrate. Yoneyama *et al.* (2001) reported that the production of clover broomrape seed germination stimulant was inhibited by phosphate (NaH_2PO_4) and ammonium sulfate $(NH_4)_2SO_4$. High nitrogen application was also reported to reduce parasitism of scalloped broomrape on broad beans and parasitism of witchweed on sorghum (Abu-Irmaileh, 1981).

Effects of animal manure on the parasitism of tomato plant by branched broomrape

No much work has been done on the organic fertilizer to control *Orobanche* spp. As the results indicated, the higher average number and dry weight of branched broomrape shoots and the lowest yield were obtained from untreated pots. The recommended fertilizer without parasitic weed gave the yield of tomato equal to that by the application of goat manure at 20 and 30 t/ha with parasitic weed (Table 4). As the weight of manure increased, the average number and dry weight of branched broomrape decreased and yield increased linearly. The application of goat manure at 20 and 30 t/ha reduced branched broomrape infestation effectively but the rate of 30 t/ha reduced more. This might be due to high content of nitrogen compound (Table 2). There was no significant difference of yield between these two rates of goat manure. That goat manure at 20 t/ha could be adequate to reduce parasitism of branched broomrape in tomato. This result agreed with Haidar *et al.* (2002), who indicated that goat manure 20 t/ha significantly reduced *Orobanche ramosa*

Table 3 Effects of nitrogen fertilizer on the parasitism of tomato plant by branched broomrape.

Treatment	Fertilizer rate (kg/ ha)	Tomato: Shoot Height (cm)	Tomato: Shoot Dry wt. (g/pt)	Tomato: Root Length (cm)	Tomato: Root Dry wt. (g/pt)	Tomato: Fruit (no/pt)	Tomato: Yield (g /pt)	Branched broomrape: No. of parasite / tomato pt	Branched broomrape: Shoot dry wt. (g/ tomato pt)
No- N – parasite		57.0 e[1/]	25.0 de	41.0 c	4.0 bc	7.0 bc	444.0 bc	0.0 a	0.0 a
No- N + parasite		38.0 a	16.0 a	25.0 a	3.0 a	3.0 a	147.0 a	21.0 g	5.5 f
Urea + parasite	69 N	46.0 b	23.0 bc	33.0 b	4.0 ac	6.0 b	390.0 bc	15.0 e f	3.7 e
Urea + parasite	138 N	56.0 de	28.0 f	42.0 c	5.0 c	8.0 cd	516.0 cd	10.0 c	2.4 cd
Urea + parasite	207 N	73.0 g	33.0 g	46.0 d	7.0 d	9.0 de	657.0 e	5.0 b	1.4 b
Urea + parasite	276 N	84.0 h	37.0 h	49.0 d	11.0 e	10.0 e	768.0 e	3.0 b	0.7 ab
NHO_4NO_3 + parasite	69 N	50.0 bd	23.0 c	33.0 b	3.0 ab	7.0 bc	441.0 bc	13.0 de	3.4 e
NHO_4NO_3 + parasite	138 N	71.0 g	27.0 ef	40.0 c	4.0 ac	8.0 cd	531.0 d	9.0 c	2.3 d
NHO_4NO_3 + parasite	207 N	86.0 h	37.0 h	48.0 d	11.0 e	10.0 e	771.0 e	3.0 b	0.8 ab
NHO_4NO_3 + parasite	276 N	54.0 be	24.0 cd	35.0 b	3.0 a	7.0 bc	471.0 bc	3.0 b	0.6 b
$(NHO_4)_2SO_4$ + parasite	69 N	48.0 bc	21.0 b	32.0 b	4.0 ab	6.0 b	375.0 b	16.0 f	3.8 e
$(NHO_4)_2SO_4$ + parasite	138 N	61.0 f	25.0 de	41.0 c	5.0 c	7.0 bc	471.0 bc	11.0 cd	2.7 d
$(NHO_4)_2SO_4$ + parasite	207 N	73.0 g	32.0 g	46.0 d	7.0 d	9.0 de	648.0 e	5.0 b	1.1 bc
$(NHO_4)_2SO_4$ + parasite	276 N	55.0 ce	22.0 bc	35.0 b	4.0 ac	7.0 bc	435.0 bc	4.0 b	1.0 bc
C.V %	7.92	4.5		7.03	10.62	22.83	18.77	19.64	25.5

[1/] Means followed by the same letters within the same column are not significantly different according to Duncan's multiple range test at 5%level

Table 4 Effects of animal manure on parasitism of tomato plant by branched broomrape.

Treatment	Nutrient rate (t / ha)	Tomato						Branched broomrape	
		Shoot		Root		Fruit	Yield	No. of	Shoot
		Height (cm)	Dry wt. (g/pt)	Length (cm)	Dry wt. (g/pt)	(no./pt)	(g/pt)	parasite/ tomato pt	dry wt. (g/ tomato pt)
No- N fertilizer - parasite		50.0 bd[1/]	22.0 e	33.0 df	5.0 ab	7.0 bc	414.0 bd	0.0 a	0.0 a
No- N fertilizer + parasite		36.0 a	12.0 a	20.0 a	2.0 a	3.0 a	117.0 a	23.0 h	6.4 j
Recommended fertilizer - parasite	138 kg N + 92 kg P	65.0 g	37.0 i	47.0 i	9.5 e	10.0 e	759.0 e	0.0 a	0.0 a
Recommended fertilizer + parasite	138 kg N + 92 kg P	56.0 de	25.0 f	36.0 ef	7.0 bc	8.0 cd	513.0 d	9.0 d	1.6 cd
Chicken manure + parasite	10	44.0 b	14.0 ab	22.0 ab	3.0 ab	6.0 b	330.0 b	16.0 g	4.2 I
Chicken manure + parasite	20	53.0 de	18.0 cd	29.0 fg	4.0 cd	7.0 bc	423.0 bd	13.0 ef	2.8 fg
Chicken manure + parasite	30	58.0 e	24.0 ef	36.0 hi	6.0 cd	8.0 cd	507.0 cd	10.0 d	1.8 de
Cow manure + parasite	10	46.0 b	16.0 bc	24.0 ac	3.0 ab	6.0 b	348.0 b	16.0 g	4.0 hi
Cow manure + parasite	20	54.0 ce	19.0 d	30.0 ce	5.0 bc	7.0 bc	438.0 bd	12.0 e	2.4 ef
Cow manure + parasite	30	59.0 e	25.0 ef	37.0 ef	6.0 ce	8.0 cd	519.0 d	9.0 d	1.4 cd
Goat manure + parasite	10	47.0 bc	19.0 d	28.0 bd	4.0 bc	6.0 b	381.0 bc	14.0 f	3.4 gh
Goat manure + parasite	20	58.0 e	29.0 g	39.0 fh	7.0 de	9.0 de	645.0 e	6.0 c	1.1 bc
Goat manure + parasite	30	61.0 fg	34.0 h	44.0 gi	9.0 e	10.0 e	726.0 e	3.0 b	0.6 ab
C.V %		7.8	8.4	12.5	27.0	20.8	17.2	12.3	19.9

[1/] Means followed by the same letters within the same column are not significantly different according to Duncan's multiple range test at 5%level infestation throughout the growing season in potato.

The higher rates (30 t/ha) of cow and chicken manure also gave good reduction of branched broomrape. There was no significant difference between these two treatments. However, goat manure at 20 t/ha was more effective and economical to reduce branched broomrape as compared with cow and chicken manures at 30 t/ha (Table 4). Not only animal manure but the green manure also reduces broomrape infestation. Ghosheh *et al*. (1999) revealed that olive jift (a solid by-product of olive) in soil also reduced broomrape infections.

Branched broomrape infestation of tomato decreased with increases of soil nitrogen. Because of the complex interaction among host, parasite, and the environment, it has been difficult to determine the mechanism by which N reduces branched broomrape infestation. The different experiments pointing to different nutrient or soil factors may indicate that the nutrients are influencing the host parasite relationship in more than one way (Westwood and Foy, 1999). As reviewed by Jain and Foy (1992), some researchers have reported that the addition of manure and certain synthetic nitrogenous fertilizers result in improved crop yields due to a detrimental effect of the fertilizers on the parasitic infestations, but others have attributed the beneficial effects of nitrogenous fertilization directly to improve crop performance and tolerance to attack by parasite. Abu-Irmaileh (1994) reported that the mechanism by which nitrogen affecting seed germination might be through its effect on reducing potassium uptake, since broomrape seeds had a high demand for potassium. In other parasitic weeds as reviewed by Westwood and Foy (1999), who suggested that nitrogen reduced damage by witchweed (*Striga hermontica*) growing on sorghum by enhancing the host's ability to maintain a favorable osmotic potential. Several authors reported direct toxicity by nitrogen fertilizers to seeds of broomrape and witchweed. Westwood and Foy (1999), reported nitrogen in ammonium form to be more inhibitory than nitrate but they concluded that it was the elongation of the seedling radicle that was primarily inhibited by ammonium, rather than the seed germination itself.

CONCLUSION

The influence of nitrogen from inorganic fertilizers (NH_4NO_3, $(NH_4)_2SO_4$, $NH_2CO NH_2$) and organic fertilizers (chicken, cow, goat manure) on parasitism of tomato plant by branched broomrape was investigated on sandy loam soil in pot experiments. The results revealed that urea, ammonium nitrate, and ammonium sulfate at 207 kg N/ha and the goat manure at 20 t/ha were effective in reducing parasitism and enhancing growth of tomato plants. Hence, the effect of these nitrogen fertilizers and animal manure should be tested in the field.

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