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Screening of Tomato (*Lycopersicon esculentum* Mill.) Varieties for Resistance to Branched Broomrape (*Orobanche ramosa* L.)

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ABSTRACT

Thirty tomato varieties were evaluated for branched broomrape resistance in pot experiments under natural conditions in Central Rift Valley of Ethiopia. The susceptible variety of tomato Roma VFN was used as a control. Percent yield loss of tomato due to branched broomrape was used as a main parameter and number and dry weight of branched broomrape shoot per tomato plant, were used as support parameters. Results revealed that the highest levels of resistance were found in varieties, LE 244, LE 180 A, South Africa, CLN 2123 A, Florida MHI UCG, Riogrande, Melekashola and Seedathip, with yield losses of 32% to 43% and numbers of parasite per plant were 7.0 to 13.0. Caribe and Floradade varieties were found to be highly susceptible to branched broomrape with yield losses 74% and 75% respectively. Thirty one and thirty three branched broomrape shoots developed on their roots. The percent yield loss (37%) of South Africa variety seemed minimal compared to the varieties parasitized by lower and equal number of branched broomrape. This indicated that South Africa variety was less affected by the parasite.

Key words: branched broomrape, tomato varieties, resistance, tolerance, parasitic weeds

INTRODUCTION

Parasitic plants of the genus *Orobanche* (broomrapes) connect to dicotyledonous host plants using a special intrusive multicellular organ, the haustorium, and deprive water and nutrients from them. Broomrapes are holoparasitic, devoid of leaves and totally dependent on their hosts. Survival of the parasite depends on its ability to establish contact with a host and to develop an haustorium. Each broomrape plant produces thousands of tiny seeds that remain viable in the soil for many years, allowing a rapid increase of the parasite seed bank in agricultural soil. Normal development of the parasite starts with seed germination that comes in response to the reception of a chemical stimulus from host roots (Zhou *et al*., 2004).

The branched broomrape (*Orobanche ramosa* L.) is a wide-spread destructive root parasite of many crop plants. Tomato (*Lycopersicon esculentum* Mill.) is important vegetable crop highly susceptible to and damaged by *O. ramosa*. Severe infestation of tomato field by this parasite seriously reduces yield and can lead to total crop failure (Kasrawi and Abu-Irmaileh, 1989).

Several strategies to control branched broomrape have been developed from cultural practices to chemical control but none has succeeded, being either not feasible, uneconomic, hard to achieve or resulting in incomplete

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protection. The search for resistant tomato cultivars to this parasite becomes of great economic importance. The use of resistant cultivars are the most economical, feasible and environmental-friendly method of control. Host genetic resistance is also generally considered critical to successful integrated pest management programs (Goldwasser *et al*., 2001; Joel, 2000; Morozov *et al*., 2000; Rubiales *et al*., 2003; Westwood and Foy, 1999).

Useful levels of resistance have been found in several hosts against parasitic plants, like in sorghum against *Striga hermonthica* and cowpea against *S. gesnerioides* (Rubiales *et al*., 2003), sunflower against *O. cumana* (Kasrawi and Abu-Irmaileh, 1989), fababean (Alders and Pieterese, 1986), chickpea (Cubero, 1991) and vetch (Gil *et al*., 1984) against *O. crenata*, egg plant against *O. cernua* (Dalela and Mathur, 1971). Most attempts to select *Orobanche*-resistant tomato varieties have yielded only a range of varying susceptibility. Dalela and Mathur (1971) found only one line 'moderately resistant' to *O. cernua* out of 41 studied. Abu-Gharbieh *et al*. (1978) found only 'slightly resistance' to *O*. *ramosa* in 8 out of 100 lines studied. Saghir *et al*. (1980) found slightly tolerant to *O. ramosa* in 8 out of 108 cultivars. Abedeev and Scherbinin (1982) developed PZU-11, a tomato line uniformly resistant to *O. aegyptiaca*. However, the resistance of PZU- 11 was lost when retested in other location (Foy *et al*., 1987). Hence, this experiment was initiated to find out tomato varieties resistance to branched broomrape in Ethiopia.

MATERIALS AND METHODS

A pot experiment was carried out under natural conditions (open field) at Melkasa Agricultural Research Center, Ethiopia. Randomized complete block design with three replications were used as an experimental design. Thirty varieties of tomato with and without parasites were used as treatments. Roma VFN was used as susceptible control. Twenty varieties were provided by Melkasa Agricultural Research Center, Horticulture Division, Ethiopia and other ten varieties were provided by Asian Vegetable Research and Development Center (AVRDC), Thailand.

Seeds of branched broomrape were collected from plants parasitizing tomato in Nura Era state farm. Soil and sand were sterilized in oven at 105°C for 24 hours before planting. Plastic pots (22 cm diameter) of 18 cm height with holes in the bottoms were filled with soil mixed (3 soil: 1 sand) 4 kg per pot. The soil was sandy loam with pH of 7.8 and electrical conductivity 0.449. A 100 mg of branched broomrape seeds were mixed with 200 g sand and thoroughly mixed with 600 g soil by passing through a plastic funnel five times in each case and added to the upper 2 cm of the pots. Ten seeds of tomato were sown directly to each pot. The pots were irrigated with 200 ml of tap water every day and seedling production and preconditioning of branched broomrape were done together. After one month the tomato seedlings were thinned to one plant per pot. The newly emerged branched broomrape shoots were counted every week and the older pulled out. Once emerged they dried within two weeks and were difficult to take their fresh weights. The plants grown in the open with the average air temperature and rainfall over the growing period were 22.36°C and 118.32 mm respectively.

Ripen tomato fruits were harvested starting from the fourth month after sowing date every week for four times. At the end of the experiment the soil was washed carefully from the roots, and the number of un-emerged branched broomrape shoots were taken, mixed with emerged branched broomrape shoots and dried in the oven at 70°C for 48 hours (Kasrawi and Abu- Irmaileh, 1989; Saghir *et al*., 1980). The data collected were numbers and dry weights of branched broomrape shoot and fruit yield of tomato. Numbers and dry weights of branched broomrape shoot and percent yield losses subject to analysis of variance and the means were separated by Duncan's multiple range test at 1% level of significance. The percent yield loss values of a-d, e-i, j-l, m-o and p were used as criteria to classify varieties as highly resistant, moderately resistant, slightly resistant, susceptible and highly susceptible respectively.

RESULTS AND DISCUSSION

Thirty tomato varieties were evaluated for branched broomrape resistance in pot experiments under natural conditions. Tomato variety Roma VFN was used as a susceptible control. Percent yield loss of tomato due to branched broomrape was used as main parameter and number and dry weight of branched broomrape shoot per tomato plant were used as support parameters. Highly significant differences were obtained between the control and other varieties (Table 1). Findings indicated that out of the 30 varieties, 8 were highly resistant to branched broomrape parasitism. These included LE 244, LE 180 A, South Africa, CLN 2123 A, Florida MHI UCG, Riogrande, Melkashola, and Seedathip. Low percents of yield loss, 32% to 43%, low numbers of branched broomrape shoot per tomato plant, 7.0 to 13.0 and low dry weights of branched broomrape shoot per tomato plant, 1.6 to 2.9 g were obtained from these varieties. Eleven varieties, Cherry, Floralou, CLN 1621 L, CL-5916-206-04-2-2-0, CL-5915-206-D4-2-5-0, H 24, H 1350, Cerise, Cardinal, Calipso and Marglobe improved were found to be moderately resistant. Medium percents of yield loss 45% to 55%, medium numbers of branched broomrape shoot per tomato plant 11.0 to 17.0 and medium dry weight of branched broomrape shoots per tomato plant 2.7 to 3.5 g were obtained from these varieties. Four varieties, VFN-138, CLN 1621 J, CLN 2026 D and Melkasalsa were found to be slightly resistant. High percents of yield loss, 57% to 61%, high numbers of branched broomrape shoot, 18.0 to 19.0 and medium dry weights of branched broomrape shoot, 4.1 to 4.6 g per tomato plant were obtained from these varieties. Other four varieties, CLN 2116 B, CLN 1314 G, CLN 1621 P and Missuri were found to be susceptible. High percents of yield loss, 63% to 68%, high numbers of branched broomrape shoot, 20.0 to 23.0 and high dry weights of branched broomrape shoot per tomato plant were obtained. The remaining two varieties Caribe and Floradade were found to be highly susceptible. Higher percents of yield loss, higher numbers and dry weights of branched broomrape shoot per tomato plant than the control were obtained.

There were similar trends between number and dry weight of branched broomrape shoot. As the number of branched broomrape shoots increased, dry weight of branched broomrape shoots also increased.

In variety such as South Africa, the number of parasite medium except the percent yield loss was lower compared to the varieties parasitized by lower and equal number of branched broomrape. This might indicate that variety South Africa was less affected by this parasite.

According to Parker and Riches (1993), the term tolerance was used for the reaction of varieties parasitized to the same extent but suffered less damage than standard varieties. The converse of tolerance is sensitivity. The term resistance applies to varieties showing less attack, usually in terms of numbers of parasite attached or emerged. Resistance is rarely complete and, where necessary, the term partial resistance implies significantly less attack compared with standard varieties ('tolerance' is sometimes used wrongly for this reaction), while total resistance is usually referred to as immunity. The converse of resistance is susceptibility.

The results of this experiment indicated there were variations among varieties for branched broomrape resistance. These could be due to different reasons. As reviewed by Kasrawi and Abu-Irmaileh (1989), the host might resist the development of the parasite at three stages of its life cycle: seed germination, haustoria formation, and development of flowering shoots. In resistant variety, the resistance is due to low stimulant exudation (Parker and Riches, 1993). The findings by Goldwasser *et al.* (1999) suggested that secondary metabolieties might involve in the defense mechanism(s) of the resistant vetch host, forming mechanical and chemical barriers against the invading parasite. Mechanisms by which

Table 1 Responses of different tomato variety to branched broomrape.

Tomato varieties	No. of parasite/ tomato pt.	Shoot dry wt. of parasite (g/tomato pt.)	Tomato fruit yield with parasite (g/pt.)	Tomato fruit yield without parasite (g/pt.)	Tomato fruit yield loss (%)
Roma VFN	26.0 r [1/]	6.5 q	113 b	417 n	73 p [2/]
Calipso	15.7 j	3.6 j	203 gh	435 qr	53 h
Cardinal	14.7 i	3.6 j	231 hi	495 u	53 h
Caribe	30.7 s	6.9 r	111 b	433 q	74 p
Cerise	14.0 i	3.2 i	224 i	448 t	50 g
Cherry	10.7de	2.4 cd	176 de	321 f	45 ef
CL-5915-206-D4-2-5-0	13.7 h	3.0 gh	184 ef	344 k	47 f
CL-5916-206-04-2-2-0	11.7 f	2.7 ef	181 ef	334 I	46 f
CLN 1314 G	21.7 o	5.0 n	114 b	320 f	64 mn
CLN 1621 J	18.7 m	4.1 kl	144 c	336 i	57 jk
CLN 1621 L	12.7 g	2.9 fh	218 i	404 l	46 f
CLN 1621 P	22.0 p	5.3 o	141 c	416 n	66 no
CLN 2026 D	18.7 m	4.6 m	123 b	313 d	61 l
CLN 2116 B	19.7 n	4.8 n	114 b	309 c	63 m
CLN 2123 A	8.7 b	2.3 bc	186 ef	300 a	38 b
Floradade	32.7 t	7.2 s	94 a	410 m	75 p
Floralou	10.7 de	2.6 de	184 ef	341 j	46 f
Florida MHI UCG	9.0 c	2.1 b	164 d	315 e	40 c
H 24	10.0 d	2.2 b	162 d	312 d	50 g
H 1350	10.7 de	3.1 hi	162 d	323 g	50 g
LE 180 A	11.0 ef	2.7 ef	173 de	305 b	43 de
LE 244	7.0 a	1.6 a	268 l	426 p	32 a
Marglobe improved	16.7 k	3.5 j	188 ef	418 n	55 ij
Melkasalsa	18.7 m	4.3 l	174 de	434 q	60 l
Melkashola	11.7 f	2.8 eg	255 k	440 s	42 cd
Missuri	23.7 q	5.9 p	125 b	324 g	68 o
Riogrande	9.7 c	2.3 bc	191 fg	330 h	42 cd
Seedathip	10.7 de	2.4 cd	240 j	423 o	43 de
South Africa	13.0 h	2.9 fh	274 l	436 r	37 b
VFN-138	17.7 l	4.3 l	170 c	334 i	58 k

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

[2/] Percentage yield loss was calculated from yield without parasite deducted by yield with parasite, divided by yield without parasite and multiplied by 100 varieties show greater tolerance than others have been little studied but are likely to receive greater attention in the future.

CONCLUSION

The use of resistant crop varieties is viewed as the most reliable and economically feasible means of *Orobanche* control. Selection should be performed on varieties which showed promising resistance such as, LE 244, CLN 2123 A, Florida, MHI UCG, Riogrande, H 24, Cherry, Floralou, H 1350, Seedathip, LE 180 A, CL-5916-206-04-2-2-0, Melkashola, CLN 1621 L, South Africa, CL-5915-206-D4-2-5-0, Cerise, Cardinal, Calipso and Marglobe and should be improved in naturally infested fields at different locations. Therefore, it seems to obtain promising resistant varieties as potentially good sources for developing new resistant varieties or obtaining varieties directly put on production.

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