E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2023; 6(2): 29-33
Received: 07-05-2023
Accepted: 17-06-2023

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Host specific races of *Phelipanche aegyptiaca*

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DOI: https://doi.org/10.33545/2618060X.2023.v6.i2a.182

Abstract
The aim of the present study was to identify the distinct races in *Phelipanche aegyptiaca* (*Orobanche aegyptiaca* Pers.) parasitizing different crops in Banda district of Provision Uttar Pradesh, Republic of India. One hundred isolates of *O. aegyptiaca* infecting brinjal were randomly collected from different fields of Banda district. The collected seeds (isolates) were used to inoculate in a set of nine differential hosts. The inoculated plant with one or more emerged broomrape spikes was designated as susceptible (+), whereas, the host plant without spike was designated as non-host (-). Two physiological races of *Orobanche aegyptiaca* were found. Race A of *O. aegyptiaca* infected all the differential host plants whereas, race B only infected eggplant, chili, fenugreek, mustard, chickpea and tomato. Carrot, linseed and sunflower were not hosts of race B. These findings showed that the Race-A is more virulent on brinjal, tomato, and mustard crops as compared Race-B. Whereas, Race-B is more virulent on chickpea. To the best of our knowledge, so far no information is available regarding the parasitism on fenugreek and linseed. Hence this document served the first report of *P. aegyptiaca* infection on fenugreek and linseed from India as well as abroad. These findings may be useful in the management practices like in crop rotation and development of the species or race specific resistant varieties of brinjal.

Keywords: *Solanum melongena*, *Orobanche aegyptiaca*, *Phelipanche aegyptiaca*, holo-parasite, Race A and B

Introduction
Parasitic plants can be classified as hemi-parasites, which are photosynthetic, and holo-parasites, which are devoid of chlorophyll and dependent on the host plant for nutrition (Rubails 2018) [16]. The genus, *Orobanche*, common name broomrape, includes more than 150 described species, most of them cause damage to a range of hosts (Parker and Riches, 1993; Akhter and Khan, 2018a-c; Akhter *et al*., 2018 a, b) [4, 3, 4-5, 13]. The most destructive species are *O. aegyptiaca*, *O. cernua*, *O. cumana*, *O. crenata* and *O. minor* (Parker 2012) [12]. In India, three species of *Orobanche viz*., *O. aegyptiaca*, *O. crenata* and *O. ramosa* have been reported from eggplant (*Solanum melongena* L.) (Kannan *et al*., 2014; Kanwar 2017; Akhter and Khan 2018 and Akhter and Khan 2020) [8, 9, 1-2, 6]. Among the *Orobanche* spp., *O. aegyptiaca* (*Phelipanche aegyptiaca*)may attack carrot, eggplant, potato, chickpea and sunflower. Broomrape may reduce yield of crops by 50% or more, especially where soil moisture is lacking (Singh 2017; Prasad *et al*. 2009) [19, 15].
Accurate identification of broomrapes up-to species level is very important for suggesting proper disease management through use of resistant varieties. But to make this to be successful, the knowledge of the race and virulence characteristic of the locally occurring populations of parasitic weeds is also required. To date, two races of *P. aegyptiaca* have been reported from Israel by Jacobsohn *et al.* (1990) [7]. Moreover, eight races of sunflower broomrape (*O. cumana*) have been identified by using international standard race differential hosts in Bulgaria, Serbia, Romania, Turkey, China and Russia (Molinero- Ruiz *et al*.2015; Shi *et al*. 2015; Shindrova *et al*. 2012) [10, 17, 18] and three host specific strains of *O. minor* has been reported by Muselman and Paker (1982) [21]. However, so far the identification and distribution of races of *P. aegyptiaca* have not been reported from, India. Therefore, the present study was under taken to identify races of *O. aegyptiaca* infecting brinjal growing in Banda district of Uttar Pradesh, India.

Materials and Methods

For the identification of races of *P. aegyptiaca* infecting brinjal, a survey of 20 different localities *viz.,* Atarra, Barokhar, Bisanda, Chilla, Gazipur, Hardauli, Jalalpur, Jakhni, Jamwara, Jaspura, Kalinjar, Kurrahi, Lakhanpur, Mahua, Naraini, Oran, Palhari, Pangara, Reona and Tarkhari of Banda district of Uttar Pradesh was carried out from January to April, 2015. From each locality, five dried spikes (isolates) of *O. aegyptiaca* infecting brinjal were randomly collected from different fields. These spikes were kept separately in properly labelled polyethylene bags and taken to laboratory, Department of Botany, Aligarh Muslim University Aligarh for race identification. The seeds were separately collected from each spike and were stored in dark at 4 °C till further use. The collected seeds were used to inoculate in a set of nine differential hosts *viz.* brinjal (*Solanum melongena* var. Sukdha), carrot (*Daucus carota* var. Redking) chickpea (*Cicer arietinum* var. Avrodhi), chili (*Capsicum annuum* var. US 917), fenugreek (*Trigonella foenum-graecum* var. UM-12), linseed (*Linum usitatissimum* var. Padmini**)**, mustard (*Brassica juncea* var. Pusa mustard 24) sunflower (*Helianthus annuus* var. Advanta) and tomato (*Solanum lycopersicum* var. K-21). Since the infection of *O. aegyptiaca* on these plants were encountered during the survey of Banda district, therefore, these plants were included in the present investigation as differential hosts.

Before inoculation, the preconditioning of surface sterilized seeds of *P. aegyptiaca* was done according to Plakhine *et al.* (2009) [14]. Out of nine different host cultivars, the seeds of six hosts *viz*., chickpea fenugreek, carrot, linseed, mustard and sunflower were sown @5 seeds per earthen pots. After germination, thinning of one week old seedlings was done leaving only one seedling/ pot. Whereas, the two week old seedlings of remaining three plants *viz.*, brinjal, chili and tomato were transplanted singly per pot. The height of each pot was six inches and contained mixture of 1 kg sterilized soil and farmyard manure in the ratio of 3:1. Three week old seedlings of these plants were inoculated with preconditioned seeds of *P. aegyptiaca*. The top layer of the soil was carefully removed just before the inoculation to expose the root system and roots of the seedlings were artificially inoculated with seeds of *P. aegyptiaca* @ 8 mg seeds/pot. For inoculation, 10 g soil infested with 8mg broomrape seeds was sprinkled uniformly all around the exposed roots of the test plant with the help of common salt sprinkler.

Thereafter, exposed roots were immediately covered after inoculation by leveling the soil properly. Each pot was replicated three times. The pots were arranged in complete randomized block designs in an open field. The pots were irrigated as and when required. The newly emerged *P. aegyptiaca* shoots/ spikes were counted periodically and experiment was terminated after 90 days of inoculation. The inoculated plant with one or more emerged broomrape spikes was designated as susceptible (+), whereas, the host plant without spike was designated as non-host (-).

Results

The data presented in Table-1 clearly revealed that out of 100 isolates of *P. aegyptiaca* infecting brinjal plants in localities of Banda district, 81 isolates were able to infect all the nine hosts tested *viz.*, brinjal, carrot, chili, fenugreek, linseed, tomato, tobacco, mustard and sunflower. However, on the other hand out of the nine crops tested, three crops *viz*., carrot, linseed and sunflower were the non-host for the 19 isolates as there was no emergence of spike of *P. aegyptiaca* and remaining six crops *viz.*, brinjal, chili, fenugreek, tomato, tobacco and mustard showed susceptible reaction against these isolates. These results indicated that two types of populations of *P. aegyptiaca* were found to be associated with brinjal crop growing in Banda district. The population which infect all the nine tested crops was designated as *P. aegyptiaca* Race- A. Whereas, the population which showed non-host response to carrot, linseed and sunflower indicated as *P. aegyptiaca* Race-B. Further, it was observed that the intensity of infection of both the races in term of number of spikes of *P. aegyptiaca* emerged/plant varied on differential hosts. The average number of spikes of Race-A population in brinjal, tomato, and mustard plants were significantly higher as compared to spikes produced by Race-B. However, on the other hand Race-B significantly produced more spikes in chickpea in comparison to Race- A. It was interesting to note that there was no significant variation in between the number of spikes produced by Race-A and Race-B in fenugreek (Table 2).

Table 1: Identification of races of *P. aegyptiaca* infecting brinjal growing in Banda district of Uttar Pradesh, India

Localities	Differential host plants/Average number of broomrape spike per plant									
	Brinjal var. Sukdha	Chili var. US 917	Tomato var.K-21	Chickpea var. Avrodhi	Fenugreek var. UM-12	Carrot var. Red king	Linseed var. Padmini	Mustard var. Pusa Mustard 24	Sunflower var. Advanta	Race of *O.aegyptiaca*
Attara-1	+* (17.67)	+ (3.33)	+ (17.67)	+ (4.00)	+ (10.33)	+ (5.33)	+ (6.67)	+ (10.33)	+ (12.67)	A
Attara-2	+ (19.67)	+ (4.67)	+ (15.67)	+ (7.67)	+ (8.33)	+ (7.33)	+ (5.67)	+ (12.33)	+ (13.33)	A
Attara-3	+ (18.67)	+ (5.33)	+ (18.67)	+ (11.33)	+ (10.33)	+ (2.33)	+ (6.67)	+ (11.00)	+ (12.33)	A
Attara-4	+ (20.67)	+ (5.00)	+ (16.67)	+ (8.00)	+ (10.67)	+ (5.00)	+ (7.33)	+ (11.00)	+ (13.00	A
Attara-5	+ (21.33)	+ (2.33)	+ (14.33)	+ (4.00)	+ (10.33)	+ (5.33)	+ (6.67)	+ (10.33)	+ (12.67)	A
Barokhar-1	+ (22.33)	+ (4.67)	+ (15.33)	+ (7.67)	+ (11.33)	+ (4.67)	+ (8.00)	+ (12.00)	+ (15.33)	A
Barokhar-2	+ (18.33)	+ (3.67)	+ (18.33)	+ (11.33)	+ (10.33)	+ (5.67)	+ (6.67)	+ (11)	+ (12.33)	A
Barokhar-3	+ (20.33)	+ (2.33)	+ (14.33)	+ (11.33)	+ (10.33)	+ (3.67)	+ (6.67)	+ (11.00)	+ (12.33)	A
Barokhar-4	+ (19.67)	+ (2.67)	+ (14.67)	+ (12.67)	+ (6.67)	+ (4.00)	+ (9.00)	+ (11.00)	+ (12.67)	A
Barokhar-5	+ (22.00)	+ (3.33)	+ (13.33)	+ (14.33)	+ (3.33)	+ (4.67)	+ (8.00)	+ (13.33)	+ (12.33)	A
Bisanda-1	+ (19.67)	+ (1.33)	+ (15.67)	+ (9.33)	+ (6.67)	+ (5.67)	+ (8.00)	+ (12.67)	+ (14.33)	A
Bisanda-2	+ (18.67)	+ (2.33)	+ (18.67)	+ (10.00)	+ (8.67)	+ (5.67)	+ (5.00)	+ (10.67)	+ (17.33)	A
Bisanda-3	+ (20.67)	+ (3.33)	+ (20.67)	+ (8.33)	+ (8.67)	+ (5.67)	+ (5.00)	+ (12.67)	+ (14.33)	A
Bisanda-4	+ (21.33)	+ (2.33)	+ (19.33)	+ (8.67)	+ (9.00)	+ (5.33)	+ (9.00)	+ (11.33)	+ (15.67)	A
Bisanda-5	+ (22.33)	+ (3.67)	+ (16.33)	+ (10.67)	+ (8.67)	+ (5.00)	+ (5.33)	+ (15.33)	+ (17)	A
Chilla-1	+ (18.33)	+ (4.67)	+ (18.33)	+ (11.67)	+ (10.33)	+ (5.33)	+ (4.00)	+ (12.33)	+ (17.67)	A
Chilla-2	+ (20.33)	+ (4.67)	+ (15.33)	+ (9.33)	+ (13.33)	+ (3.67)	+ (4.67)	+ (11.33)	+ (12.33)	A
Chilla-3	+ (19.67)	+ (3.67)	+ (13.67)	+ (4.33)	+ (8.67)	+ (5.67)	+ (5.00)	+ (12.67)	+ (15.33)	A
Chilla-4	+ (22.00)	+ (3.33)	+ (13.67)	+ (7.33)	+ (8.00)	+ (6.00)	+ (4.33)	+ (13.00)	+ (13.33)	A
Chilla-5	+ (19.67)	+ (3.33)	+ (19.67)	+ (14.33)	+ (2.33)	+ (1.33)	+ (4.33)	+ (12.67)	+ (12.33)	A

Gazipur-1	+ (21.67)	+ (4.67)	+ (13.67)	+ (10.33)	+ (8.67)	+ (7.67)	+ (5.33)	+ (15.33)	+ (14.33)	A
Gazipur-2	+ (19.33)	+ (2.67)	+ (15.33)	+ (9.33)	+ (3.67)	+ (6.67)	+ (4.33)	+ (12.33)	+ (13.33)	A
Gazipur-3	+ (14.33)	+ (3.67)	+ (14.33)	+ (8.67)	+ (8.67)	+ (5.67)	+ (3.33)	+ (12.67)	+ (14.00)	A
Gazipur-4	+ (21.33)	+ (3.33)	+ (15.33)	+ (11.33)	+ (8.67)	+ (5.67)	+ (5.00)	+ (12.67)	+ (14.00)	A
Gazipur-5	+ (22.33)	+ (2.67)	+ (14.33)	+ (6.67)	+ (7.67)	+ (2.67)	+ (2.33)	+ (5.00)	+ (13.33)	A
Hardauli-1	+ (16.67)	+ (4.33)	+ (16.67)	+ (7.33)	+ (8.67)	+ (5.67)	+ (5.00)	+ (12.67)	+ (16.33)	A
Hardauli-2	+ (16.67)	+ (1.33)	+ (16.67)	+ (12.67)	+ (7.33)	+ (2.33)	+ (8.33)	+ (12.67)	+ (15.67)	A
Hardauli-3	+ (18.67)	+ (4.67)	+ (18.67)	+ (9.33)	+ (4.33)	+ (6.33)	+ (5.33)	+ (11.67)	+ (14.33)	A
Hardauli-4	+ (21.67)	+ (2.33)	+ (15.67)	+ (12.33)	+ (7.00)	+ (5.00)	+ (4.33)	+ (12.67)	+ (11.33)	A
Hardauli-5	+ (17.33)	+ (2.33)	+ (17.33)	+ (9.00)	+ (8.67)	+ (5.67)	+ (3.33)	+ (12.67)	+ (13.33)	A
Jakhni-1	+ (12.67)	+ (4.33)	+ (11)	+ (11.67)	+ (6.33)	- (0.00)	+ (0.00)	- (6.67)	- (0.00)	B
Jakhni-2	+ (14.33)	+ (3.33)	+ (11)	+ (10.67)	+ (8.33)	- (0.00)	- (0.00)	+ (8.67)	- (0.00)	B
Jakhni-3	+ (21.33)	+ (2.67)	+ (15.33)	+ (4.33)	+ (8.67)	+ (5.67)	+ (5.00)	+ (12.67)	+ (12.33)	A
Jakhni-4	+ (19.33)	+ (1.33)	+ (14.33)	+ (7.67)	+ (2.33)	+ (2.00)	+ (2.67)	+ (17.67)	+ (14.33)	A
Jakhni-5	+ (22.33)	+ (1.67)	+ (15.33)	+ (10.33)	+ (3.67)	+ (4.67)	+ (3.00)	+ (13.00)	+ (16.33)	A
Jalalpur-1	+ (18.33)	+ (1.67)	+ (18.33)	+ (7.33)	+ (13.33)	+ (2.00)	+ (5.00)	+ (12.33)	+ (15.67)	A
Jalalpur-2	+ (17.67)	+ (2.33)	+ (17.67)	+ (5.33)	+ (3.67)	+ (5.33)	+ (7.33)	+ (15.33)	+ (17.33)	A
Jalalpur-3	+ (18.33)	+ (1.33)	+ (15.33)	+ (8.33)	+ (13.33)	+ (2.00)	+ (5.00)	+ (12.33)	+ (15.67)	A
Jalalpur-4	+ (21.67)	+ (2.33)	+ (13.67)	+ (4.00)	+ (7.67)	+ (2.00)	+ (7.00)	+ (10.00)	+ (13.33)	A
Jalalpur-5	+ (23.33)	+ (3.67)	+ (13.33)	+ (7.00)	+ (6.67)	+ (1.67)	+ (6.67)	+ (12.67)	+ (15.33)	A
Jamwara-1	+ (22.33)	+ (2.33)	+ (14.33)	+ (9.00)	+ (8.00)	+ (2.00)	+ (8.00)	+ (12.33)	+ (13.67)	A
Jamwara-2	+ (15.33)	+ (1.67)	+ (3.33)	+ (11.33)	+ (6.67)	- (0.00)	+ (0.00)	- (8.67)	- (0.00)	B
Jamwara-3	+ (14.67)	+ (1.33)	+ (11.00)	+ (10.67)	+ (5.33)	- (0.00)	- (0.00)	+ (10.67)	- (0.00)	B
Jamwara-4	+ (15.67)	+ (3.33)	+ (7.67)	+ (9.67)	+ (8.33)	- (0.00)	- (0.00)	+ (5.33)	- (0.00)	B
Jamwara-5	+ (19.33)	+ (3.33)	+ (19.33)	+ (14.33)	+ (9.33)	+ (6.33)	+ (7.00)	+ (16.67)	+ (13.00)	A
Jaspura-1	+ (23.33)	+ (2.67)	+ (13.33)	+ (14.00)	+ (13.33)	+ (1.67)	+ (8.67)	+ (12.33)	+ (14.33)	A
Jaspura-2	+ (24.67)	+ (1.67)	+ (12.67)	+ (8.67)	+ (8.33)	+ (4.33)	+ (6.67)	+ (15.33)	+ (14.33)	A
Jaspura-3	+ (22.67)	+ (2.67)	+ (12.67)	+ (7.67)	+ (11.33)	+ (4.33)	+ (5.67)	+ (8.33)	+ (6.67)	A
Jaspura-4	+ (19.33)	+ (4.67)	+ (13.33)	+ (14.33)	+ (9.33)	+ (6.33)	+ (7.00)	+ (16.67)	+ (13.33)	A
Jaspura-5	+ (19.67)	+ (1.67)	+ (15.67)	+ (7.67)	+ (11.33)	+ (7.33)	+ (7.67)	+ (8.33)	+ (12)	A
Kalinjar-1	+ (13.67)	+ (3.33)	+ (13.00)	+ (16.67)	+ (4.33)	- (0.00)	- (0.00)	+ (10.67)	- (0.00)	B
Kalinjar-2	+ (17.33)	+ (2.33)	+ (14.33)	+ (13.67)	+ (4.33)	- (0.00)	- (0.00)	+ (9.67)	- (0.00)	B
Kalinjar-3	+ (18.33)	+ (4.67)	+ (10.67)	+ (14.67)	+ (8.33)	- (0.00)	- (0.00)	+ (6.00)	- (0.00)	B
Kalinjar-4	+ (14.33)	+ (4.67)	+ (15.33)	+ (13.67)	+ (7.33)	- (0.00)	- (0.00)	+ (5.33)	- (0.00)	B
Kalinjar-5	+ (17.33)	+ (4.33)	+ (15.33)	+ (9.33)	+ (3.67)	+ (4.33)	+ (9.33)	+ (11.00)	+ (6.67)	A
Kurrahi-1	+ (24.67)	+ (2.67)	+ (14.67)	+ (7.67)	+ (8.33)	+ (7.33)	+ (5.67)	+ (12.33)	+ (13.00)	A
Kurrahi-2	+ (18.67)	+ (5.67)	+ (12.67)	+ (13.67)	+ (10.33)	+ (7.33)	+ (6.67)	+ (14.33)	+ (14.33)	A
Kurrahi-3	+ (19.33)	+ (4.67)	+ (14.33)	+ (10.33)	+ (6.67)	+ (3.67)	+ (7.00)	+ (13.33)	+ (15.67)	A
Kurrahi-4	+ (23.67)	+ (4.33)	+ (13.67)	+ (8.00)	+ (8.00)	+ (4.67)	+ (2.67)	+ (12.67)	+ (11.33)	A
Kurrahi-5	+ (21.33)	+ (4.33)	+ (17.00)	+ (9.00)	+ (6.67)	+ (2.00)	+ (6.67)	+ (11.67)	+ (10.00)	A
Lakhanpur-1	+ (25.67)	+ (4.67)	+ (14.67)	+ (7.67)	+ (10.33)	+ (7.33)	+ (5.67)	+ (8.33)	+ (13.67)	A
Lakhanpur-2	+ (17.67)	+ (4.33)	+ (12.67)	+ (8.33)	+ (6.00)	+ (2.00)	+ (7.33)	+ (15.67)	+ (15.33)	A
Lakhanpur-3	+ (20.33)	+ (4.67)	+ (16.33)	+ (9.00)	+ (6.67)	+ (4.67)	+ (3.33)	+ (11.00)	+ (12.67)	A
Lakhanpur-4	+ (19.33)	+ (2.33)	+ (15.33)	+ (5.33)	+ (9.33)	+ (8.00)	+ (8.33)	+ (13.33)	+ (13.67)	A
Lakhanpur-5	+ (20.33)	+ (2.33)	+ (18.33)	+ (10.00)	+ (9.00)	+ (6.33)	+ (10.00)	+ (12.67)	+ (10.33)	A
Mahua-1	+ (18.33)	+ (4.33)	+ (16.33)	+ (8.33)	+ (9.33)	+ (6.00)	+ (7.33)	+ (11.67)	+ (16.67)	A
Mahua-2	+ (25.33)	+ (5.67)	+ (15.33)	+ (8.67)	+ (7.00)	+ (6.67)	+ (6.67)	+ (12.67)	+ (14.67)	A
Mahua-3	+ (17.33)	+ (4.33)	+ (18.33)	+ (11.33)	+ (2.00)	+ (5.00)	+ (6.33)	+ (11.33)	+ (15.33)	A
Mahua-4	+ (15.67)	+ (3.33)	+ (12.67)	+ (13.67)	+ (6.67)	+ (6.33)	+ (7.33)	+ (15.33)	+ (19.67)	A
Mahua-5	+ (24.33)	+ (4.67)	+ (12.33)	+ (10.33)	+ (7.00)	+ (2.00)	+ (3.33)	+ (12.33)	+ (8.33)	A
Naraini-1	+ (17.33)	+ (1.33)	+ (13)	+ (11.67)	+ (4.33)	- (0.00)	- (0.00)	+ (10.67)	- (0.00)	B
Naraini-2	+ (21.33)	+ (4.67)	+ (17.33)	+ (14.33)	+ (6.67)	+ (2.00)	+ (7.33)	+ (15.67)	+ (7.67)	A
Naraini-3	+ (15.67)	+ (3.67)	+ (10.33)	+ (12.67)	+ (10.33)	- (0.00)	- (0.00)	+ (6.67)	- (0.00)	B
Naraini-4	+ (15.67)	+ (2.33)	+ (7.33)	+ (14.67)	+ (12.33)	- (0.00)	- (0.00)	+ (11.67)	- (0.00)	B
Naraini-5	+ (14.67)	+ (4.67)	+ (11.00)	+ (10.67)	+ (13.67)	- (0.00)	- (0.00)	+ (10.67)	- (0.00)	B
Oran-1	+ (23.67)	+ (4.33)	+ (14.67)	+ (10.33)	+ (7.00)	+ (8.33)	+ (5.67)	+ (11.67)	+ (13.00)	A
Oran-2	+ (21.33)	+ (3.33)	+ (18.33)	+ (7.33)	+ (2.00)	+ (7.33)	+ (9.00)	+ (12.67)	+ (9.00)	A
Oran-3	+ (16.67)	+ (4.67)	+ (14.67)	+ (11.67)	+ (6.67)	+ (6.67)	+ (8.00)	+ (11.33)	+ (8.00)	A
Oran-4	+ (25.67)	+ (2.67)	+ (17.67)	+ (7.67)	+ (10.33)	+ (7.33)	+ (5.67)	+ (12.33)	+ (8.33)	A
Oran-5	+ (23.33)	+ (3.33)	+ (18.33)	+ (12.00)	+ (8.67)	+ (7.00)	+ (5.33)	+ (12.33)	+ (10.33)	A
Palhari-1	+ (14.33)	+ (4.67)	+ (8.00)	+ (13.67)	+ (4.33)	- (0.00)	- (0.00)	+ (8.33)	- (0.00)	B
Palhari-2	+ (16.67)	+ (4.33)	+ (11.67)	+ (10.67)	+ (4.33)	- (0.00)	- (0.00)	+ (7.67)	- (0.00)	B
Palhari-3	+ (14.67)	+ (4.33)	+ (9.67)	+ (12.67)	+ (4.33)	- (0.00)	- (0.00)	+ (12.33)	- (0.00)	B
Palhari-4	+ (21.33)	+ (3.33)	+ (17.33)	+ (14.67)	+ (11.33)	+(3.33)	+ (4.00)	+ (8.67)	+ (12.67)	A
Palhari-5	+ (19.33)	+ (3.67)	+ (12.33)	+ (9.00)	+ (8.33)	+ (7.33)	+ (4.67)	+ (6.67)	+ (10.33)	A
Pangara-1	+ (21.67)	+ (3.33)	+ (11.67)	+ (8.33)	+ (7.67)	+ (6.67)	+ (10.67)	+ (12.67)	+ (15.67)	A
Pangara-2	+ (17.33)	+ (4.33)	+ (13.33)	+ (8.33)	+ (10.67)	+ (3.33)	+ (7.00)	+ (15.67)	+ (10.00)	A
Pangara-3	+ (17.63)	+ (1.00)	+ (17.63)	+ (7.67)	+ (4.67)	+ (7.67)	+ (8.67)	+ (13.67)	+ (9.00)	A
Pangara-4	+ (18.33)	+ (1.33)	+ (13.33)	+ (10.00)	+ (5.00)	+ (4.67)	+ (2.67)	+ (6.67)	+ (14.67)	A
Pangara-5	+ (19.67)	+ (2.33)	+ (12.67)	+ (13.33)	+ (8.00)	+ (5.67)	+ (4.67)	+ (5.67)	+ (13.33)	A
Reona-1	+ (20.67)	+ (4.67)	+ (13.67)	+ (13.67)	+ (13.33)	+ (7.33)	+ (5.67)	+ (12.33)	+ (12.00)	A
Reona-2	+ (23.67)	+ (3.67)	+ (12.67)	+ (10.67)	+ (8.33)	+ (7.33)	+ (5.67)	+ (8.33)	+ (13.67)	A
Reona-3	+ (20.67)	+ (4.33)	+ (12.67)	+ (10.67)	+ (8.00)	+ (4.00)	+ (3.33)	+ (9.33)	+ (16.67)	A
Reona-4	+ (23.33)	+ (1.67)	+ (10.33)	+ (11.33)	+ (7.67)	+ (5.33)	+ (7.33)	+ (10.33)	+ (12.33)	A
Reona-5	+ (20.67)	+ (2.33)	+ (9.33)	+ (12.00)	+ (8.00)	+ (5.67)	+ (8.67)	+ (7.33)	+ (16.33)	A
Tarkhari-1	+ (19.33)	+ (2.33)	+ (8.33)	+ (13.33)	+ (6.67)	+ (4.33)	+ (8.67)	+ (5.33)	+ (11.33)	A

Tarkhari-2	+ (18.33)	+ (4.67)	+ (18.33)	+ (11)	+ (10.33)	+ (5.00)	+ (8.67)	+ (4.33)	+ (12.33)	A
Tarkhari-3	+ (14.33)	+ (3.33)	+ (15.00)	+ (5.33)	+ (10.33)	- (0.00)	- (0.00)	+ (11.67)	- (0.00)	B
Tarkhari-4	+ (16.67	+ (1.67	+ (10.67	+ (8.33)	+ (14.33)	- (0.00)	- (0.00)	+ (10.67)	- (0.00)	B
Tarkhari-5	+ (17.67)	+ (4.67)	+ (11.00)	+ (6.33)	+ (8.67)	- (0.00)	- (0.00)	+ (9.33)	- (0.00)	B

*(+) Indicates susceptible host, (-) indicates a resistant host.
Figure in parenthesis are the number of spike per plant.

Table 2: Cumulative response of *P. aegyptiaca* races against differential host plants

Race	Differential host plants/Average number of broomrape spike per plant								
	Brinjal var. Sukdha	**Chili var. US 917**	**Tomato var.K-21**	**Chickpea var. Avrodhi**	**Fenugreek var. UM-12**	**Carrot var. Redking**	**Linseed var. Padmini**	**Mustard var. Pusa Mustard 24**	**Sunflower var. Advanta**
A	20.24 (14.33-25.67)	2.73 (1.33-3.67)	14.90 (8.33-20.67)	10.21 (4.0-14.67)	9.34 (2-13.33)	4.93 (1.33-8.00)	6.17 (2.33-10.67)	13.20 (4.33-17.67)	13.26 (6.63-19.67)
B	15.37 (12.67-18.33)	4.17 (1.33-4.67)	10.78 (3.33-15.33)	12.47 (5.33-16.67)	7.42 (4.33-14.33)	0.00	0.00	9.17 (5.33-12.33)	0.00
C.D. ($p \leq 0.05$)	4.429	0.812	3.562	2.102	2.213	-	-	3.192	-

Figure in parenthesis are range of spike/plant

Discussion

These findings showed that the Race-A is more virulent on brinjal, tomato, and mustard crops as compared Race-B. Whereas, Race-B is more virulent on chickpea. Moreover, both Race-A and B are equally virulent on fenugreek. The "Race-A" was prevalent in all the twenty localities, while "Race- B" was restricted to only in five localities *viz*., Jamwara, Kalinjar, Naraini, Palhari and Tarkhari. These are the adjoining areas of Madhya Pradesh state of India. Such virulence variability among *O. aegyptiaca* populations has also been previously documented by Jacobshon *et al.* (1990) in Israel. They reported the two races of *P. aegyptiaca*, race A inflicted heavy damage in solanaceous crops, cucurbits, sunflower, carrot, and peanut, whereas, the Race-B infect only solanaceous crop and did not infect other tested crops *viz*., cucumber, melon, watermelon, sunflower and peanut. The existence of two races namely A and B in sunflower broomrape (*O. cumana*) has also been reported from Russia in the beginnings of 20th century. Since then occurrence of eight races (A-H) have been reported in the same species (Molinero-Ruiz *et al.* 2015) [10]. Similarly, three host specific strains of *O. minor* have been reported by Muselman and Parker (1982) [21]. Thorogood *et al*. (2008) [20] observed that the genetic divergence among the populations of *O. minor* might be a consequence of host specificity.

The study, although focused on identification of races of *P. aegyptiaca* from India gave important novel insights regarding the hosts of this parasitic plant. The infection of *P. aegyptiaca* Race-A on fenugreek and linseed has been reported for the first time. To the best of our knowledge, so far no information is available regarding the parasitism on fenugreek and linseed. Hence this document served the first report of *P. aegyptiaca* infection on fenugreek and linseed from India as well as abroad. In addition to this, the brinjal plants infected by two races namely A and B of *P. aegyptiaca* in Banda district also constitute the first report from India. These results may be useful in the management practices like in crop rotation and development of the species or race specific resistant varieties of brinjal. In future, further investigations shall be conducted on host preference of other populations using these set of crops in addition to other crops, may provide better insight to the occurrence of races in *P. aegyptiaca*. Furthermore, molecular markers should be used to identify genetic divergence between Race-A and Race-B.

Acknowledgments

The authors are deeply thankful to the University Grant Commission (UGC), New Delhi, India, and the Department of Botany, A.M.U., Aligarh, for providing the necessary facilities for carrying out this research. The authors also express their gratitude to the Director General, Central Council for Research in Unani Medicine, Ministry of AYUSH, Government of India, New Delhi, 110058, India.

Disclosure statement

The authors declare no conflict of interest

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