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Galling pattern and host range studies of rice root-knot nematode (*Meloidogyne graminicola)*

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Abstract
Studies were conducted on host range and galling pattern of *M. graminicola* seven different galling patterns with divergence from the typical hook like galls were observed that are clue for the existence of new species/races. In order to identify that host range studies were conducted it includes two trials tested under glasshouses condition. The test hosts involved ten varieties of rice *viz.*, Biliya, Jyothi×Kesari, Akkalu, Jyothi, MO4, Tunga, KHP-2, JGL-1778, Kesari and Jyothi×Biliya and standard North Carolina test cultivars *ie.*, tobacco *cv.* NC 95, cotton *cv.* Deltapine 16, peanut *cv.* Florunner, tomato *cv.* Rutgers and bhendi *cv.* Arka Anamika. All the tested cultivars used in the study were infected by *M. graminicola*, except cotton and bhendi no galls are observed on these cultivars. While, tomato (5.33), tobacco (12.40) and peanut (8.00) showed least galls on root system and least Rf value (0.035), (0.061) and (0.21) respectively. However, no galls were observed on cotton and bhendi and Rf value was nil. However, the North Carolina tomato *cv.* Rutgers showed galls on root system it is clearly showed that the North Carolina tomato cv. Rutgers is an experimental host for most of root- knot nematode, but not for the species that infect cereals, like. *M. graminicola* and *M. graminis.* Hence, it is an indication that existance of new species/races in this location that needs further confirmation.

Keywords: Galling pattern, host range test, *Meloidogyne graminicola*

1. Introduction
Rice (*Oryza sativa* L.) is one of the most important staple food crops of India and is a major source of calories for about 60 per cent of world population. The crop influences the livelihoods and economies of several billion people especially concentrated in Asia, Latin America, Middle East, and the West Indies. [1] describes the integral and vital role of rice as follows "A key tenet of rice culture is that, rice is a sacred food divinely given to humans that uniquely sustains the human body in a way that no other food can". *Meloidogyne graminicola* is considered one of the species with the greatest potential for damage to irrigated rice culture, reducing productivity between 11% and 80% [2, 3]. In Karnataka, rice is grown under a variety of soils and wide range of rainfall (600 mm to 3000 mm) and temperature. In some areas, only one crop is grown and in certain other areas three crops are raised in a year. The unique feature of rice culture in the state is that either sowing or transplanting, the cultivation seen in all seasons of the year in certain areas [4]. The most prominent symptoms of *M. graminicola* on the root system are swollen and hooked root tips which are characteristic for *M. graminicola* and *M. oryzae* [5]. Typical above ground symptoms include stunting and chlorosis leading to reduced tillers and yield [6]. The *Meloidogyne* genus is considered the most important mainly due to its wide host range that includes more than 3,000 species of wild and cultivated plants [7]. The present study was initiated to identify the races of *M. graminicola* prevailing in this location by using Standard North Carolina test.

2. Material and Methods
2.1 Galling pattern
In this study different galling pattern were recorded from the collected of surveyed samples by visual and microscopic observations.

2.2 Host range of different populations of *M. graminicola*
Two trials were conducted under glasshouse condition in Department of Plant Pathology, College of Agriculture, Shivamogga using 10 cm earthen pots filled with steam-sterilized

loamy sand soil. Different rice genotypes and advanced lines *viz.*, Biliya, Jyothi×Kesari, Akkalu, Jyothi, MO4, Tunga, KHP-2, JGL-1778, Kesari and Jyothi×Biliya and standard North Carolina test cultivars *viz.*, *Nicotiana tabacum cv.* NC 95 (tobacco), *Gossypium hirsutum cv.* Deltapine16 (cotton), *Arachis hypogaea cv. Florunner* (peanut), *Solanum lycopersicum cv. Rutgers* (tomato) and Bhendi *cv.* Arka Anamika were tested for the determination of host races of *M. graminicola*. Fresh J_2 were obtained and inoculated at 1000 per pot. After 50 days, the plants were uprooted and observations were recorded in first trail the observation restricted to only reaction of host. In second trial, observation recorded such as number of galls on root system, final nematode population/200cc of soil. Rf value (Pf/Pi) and hosts were categorized as Host (+) Non host (-).

3. Results and discussion

3.1 Galling pattern

During survey on *M. graminicola* at different districts *viz.*, Shivamogga, Davanagere, Chickmagaluru, Kodagu, Mandya and Udupi districts divergence of symptoms from typical hook like galls to different galling patterns was observed and which are present in the Plate 1.

In Shivamogga district Kumsi, Gowthampura, and Konehosur recorded more number of galls in the branched roots with slightly curvature at the tip and hook like galls at the tip of branched roots (Plate 1A). Bulbous multiple galls with bunch of small galls at the mid of the root and hook like gall at the root tip at Chikadadkatte (Plate 1B). Small to beaded like galls at the root tip was found in V.C Farm Mandya (Plate 1C). Small to big uneven sized gall with rotting on midrib of the tissue was observed at Hosudi of Shivamogga (Plate 1D). Continuous multiple galls with curved end at the branched roots and bulbose galls at the tip of the root adjacent to main root at Karagunda of Chikmagaluru district (Plate 1E), round galls at the tip of the roots at Thuduru, Theerthahalli taluk Shivamogga district (Plate 1F), small discreet multiple galls at the mid of the root at Lakkavalli, Tarikere taluk, Chickmagaluru district (Plate 1G).

Plate 1: Different galling pattern of *M. graminicola* A) more number of galls in the branched roots with slightly curvature at the tip and hook like galls at the tip of branched roots; B) Bulbous multiple galls with bunch of small galls at the mid of the root and hook like gall at the root tip; C) Small to beaded like galls at the root tip; D) Small to big uneven sized gall with rotting on midrib of the tissue; E) Continuous multiple galls with curved end at the branched roots and bulbose galls at the tip of the root adjacent to main root; F) Round galls at the tip of the roots; G) Small discreet multiple galls at the mid of the root and root gall at the tip.

3.2 Host range of different populations of *M. graminicola*

The test hosts involved ten varieties of rice *viz.*, Biliya, Jyothi×Kesari, Akkalu, Jyothi, MO4, Tunga, KHP-2, JGL-1778, Kesari and Jyothi×Biliya; standard North Carolina test cultivars *ie.*, tobacco *cv.* NC 95, cotton *cv.* Deltapine16, peanut *cv.* Florunner, tomato *cv.* Rutgers and bhendi *cv.* Arka Anamika. Two trails were conducted at glasshouse and observations were recorded after 50 days on host reaction, root galling, final nematode population and Rf value results were presented in Table 1.

3.2.1 Trial-I

All the tested rice varieties were susceptible to *M. graminicola* but number of galls varied significantly. With respect to reaction on tomato, tobacco and peanut showed least galling. No galls are found in cotton and bhendi. However, all the tested rice germplasm and cultivars, tobacco, tomato and peanut are susceptible host for tested population except cotton and bhendi (Plate 2).

3.2.2 Trial-II

Similar results were observed in second trial also. All the tested cultivars used in the study were infected by *M. graminicola*, except cotton and bhendi no galls are observed on these cultivars. While, tomato (5.33), tobacco (12.40) and peanut (8.00) showed least galls on root system and least Rf value (0.035), (0.061) and (0.21) respectively. (Table 1) (Plate 3). Total gall production was maximum on all the tested rice germplasm number of galls varied from 13.40 to 184.30 and Rf value ranging from 3.19 to 9.23. However, cotton, bhendi are considered as non host for *M. graminicola.*

This study was intended to support the morphological characterization differences, if any, among the populations of *M. graminicola*. The selection of test plants was made carefully on the basis of susceptibility of rice cultivars, and other standard cultivars, as a host of *M. graminicola*. Total of 10 rice germplasms (8 varieties and 2 advance lines) namely

Biliya, Jyothi×Kesari, Akkalu, Jyothi, MO4, Tunga, KHP-2, JGL-1778, Kesari and Jyothi×Biliya; standard test cultivars *ie.*, tobacco *cv.* NC 95, cotton *cv.* Deltapine16, peanut *cv.* Florunner, tomato *cv.* Rutgers and bhendi *cv.* Arka Anmika were tested under glasshouse. The first trail it showed that all the rice germplasm were susceptible to *M. graminicola* tomato tobacco and peanut showed minute galls on root system. While, on cotton and bhendi no galling was observed. Hence *M. graminicola* was non pathogenic to bhendi and cotton. In second trail observations were taken on reaction, root galling, Rf value (Pf/Pi), and final nematode population. The major finding of this experiment is that heavy galling on all the tested rice germplasms and advanced line *viz.*, Jyothi×Biliya and Jyothi×Kesari recorded more galls and highest nematode population and serve as good host for *M. graminicola* multiplication. While, no galling was observed in cotton and bhendi and serve as non host. However, the North Carolina tomato *cv.* Rutgers showed galls on root system (plate 4) it is clearly showed that the North Carolina tomato cv. Rutgers is an experimental host for most of root- knot nematode, but not for those species that infect cereals, like., *M. graminicola* and *M. graminis* [8]. Hence, it is an indication that occurrence of new species/ races in this location. The results are in line with [9] who reported that *M. oryzae* multiplied well in tomato cv. Money Maker. [10]found that isolates of *M. graminicola* as similar in host range, but the *M. graminicola* Florida isolate differed from the other nine Nepal isolates in that it was not pathogenic to rice cv. Labelle, LA 110, Cocodrie, BR 11 or Mansuli, suggesting that *M. graminicola* consists of more than one race. [11]is attributable to taxonomic dissimilarity of Hisar population as established in this study. [12]noted significant variations in the infectivity of *M. triticoryzae* and four geographically different populations of *M. graminicola* against 27 selected crops and weeds occurring in the northern plains of India. While minor differences were observed in galling amongst the four geographical isolates of *M. graminicola* but these were not consistent enough to indicate significant infra-specific variation [13]. Evaluated the resistance/susceptibility reaction (based on number of eggs produced after completion of second life cycle by rice root-knot nematode populations) of six rice varieties (cvs. Annapurna, Ramakrishna, Tetep, Zenith, TKM-6 and Tadukan) against four *M. graminicola* populations from CRRI farms in Odisha (Amana, Kamakhyanangar, Cuttack) and in Tamil Nadu (Trichy). Except Annapurna (susceptible to all), all rice cultivars showed differential reaction pattern to nematode populations, indicating the existence of variation in virulence pattern of root-knot nematode populations. It is evident from this experiment that consideration of galling alone can be deceptive to ascertain the host status of a particular plant species; egg production is more important than gall production.

4. Conclusion

The present study implies that the existence of different galling pattern of *M. graminicola ie.*, seven different galling patterns with divergence from the typical hook like galls that were clue for the existence of new species/ races and from the host range study the North Carolina tomato cv. Rutgers showed galls on root system it is clearly showed that the North Carolina tomato cv. Rutgers is an experimental host for most of root- knot nematode, but not for the species that infect cereals, like., *M. graminicola* and *M. graminis*. Hence, it is an indication that existence of new species/races in this location.

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Table 1: Host range test of *M. graminicola*

Cultivar	Variety	Reaction		Number of galls/root system	RKI	Final nematode population (Pf)	Rf value (Pf/Pi)
		Trial-1	Trial-2				
Rice	Biliya	+	+	68.66	3.00	642.33	0.642
	Jyothi×Kesari	+	+	100.3	4.00	896.00	0.896
	Akkalu	+	+	13.40	1.00	319.66	0.319
	Jyothi	+	+	98.00	4.00	858.33	0.858
	MO4	+	+	45.33	2.00	459.66	0.459
	Tunga	+	+	35.67	2.00	402.33	0.402
	KHP-2	+	+	91.00	4.00	803.66	0.803
	JGL-1778	+	+	96.70	4.00	823.00	0.823
	Kesari	+	+	183.30	5.00	923.66	0.923
	Jyothi×Biliya	+	+	124.33	4.00	912.33	0.912
Tobacco	NC-95	+	+	8.00	1.00	65.00	0.065
Tomato	Rutgers	+	+	5.33	1.00	35.66	0.035
Peanut	Florunner	+	+	12.40	1.00	210.33	0.210
Cotton	Deltapine-61	-	-	0.00	0.00	00.00	0.00
Bhendi	Arka Anamika	-	-	0.00	0.00	00.00	0.00

+ = root galling present - = root galling absent
Pi (Initial nematode population) = 1000 J2/pot
Pf (Final nematode population)
Rf = Reproductive factor

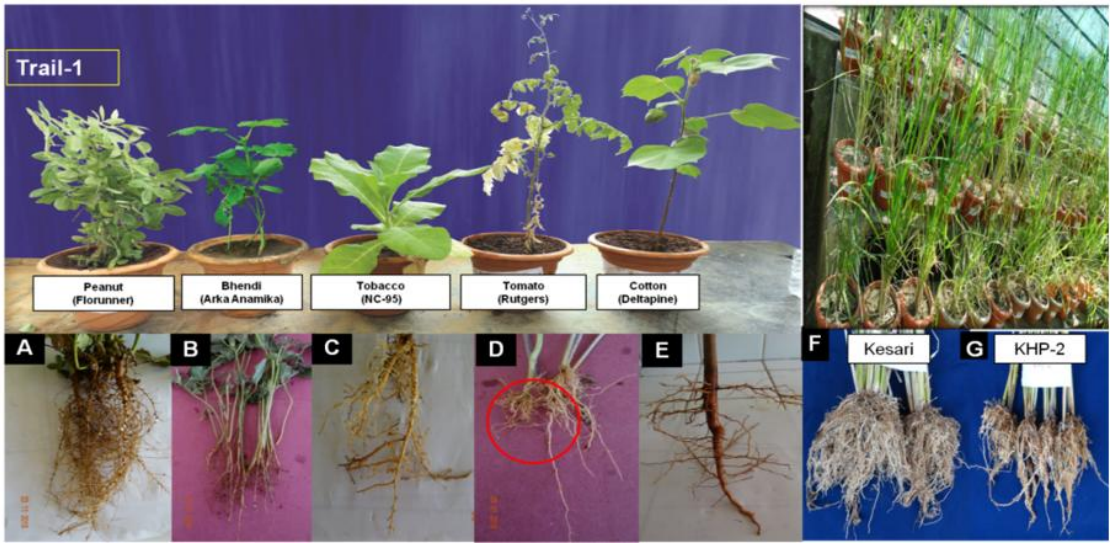

Plate 2: Host range test of *M. graminicola;* A) Peanut B) Bhendi C) Tobacco D) Tomato E) Cotton F) Rice (Kesari) (G) Rice (KHP-2)

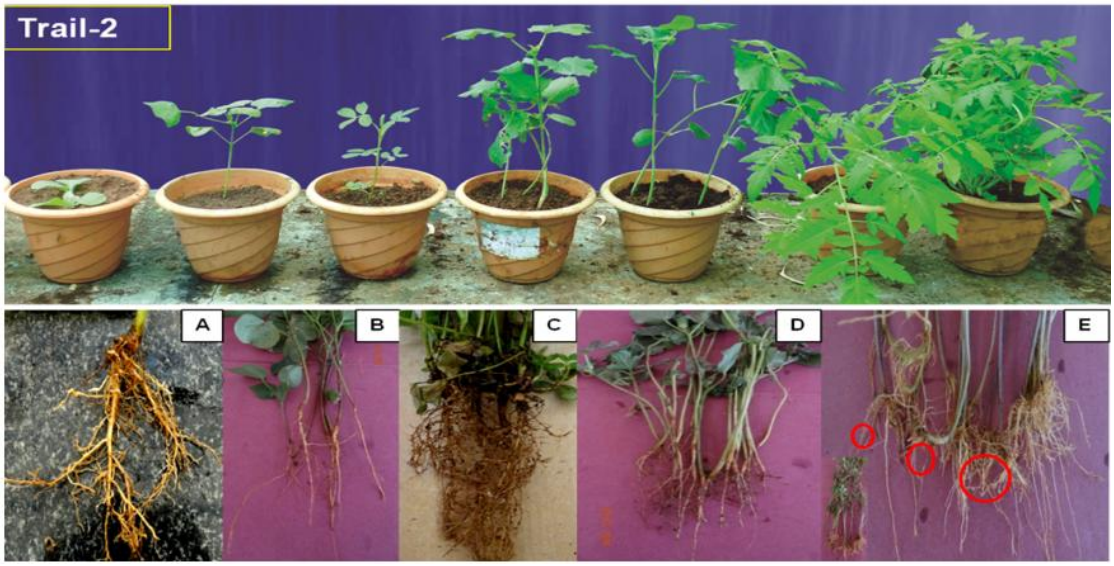

Plate 3: Host range test of *M. graminicola;* A) Tobacco B) Cotton C) Peanut D) Bhendi E) Tomato

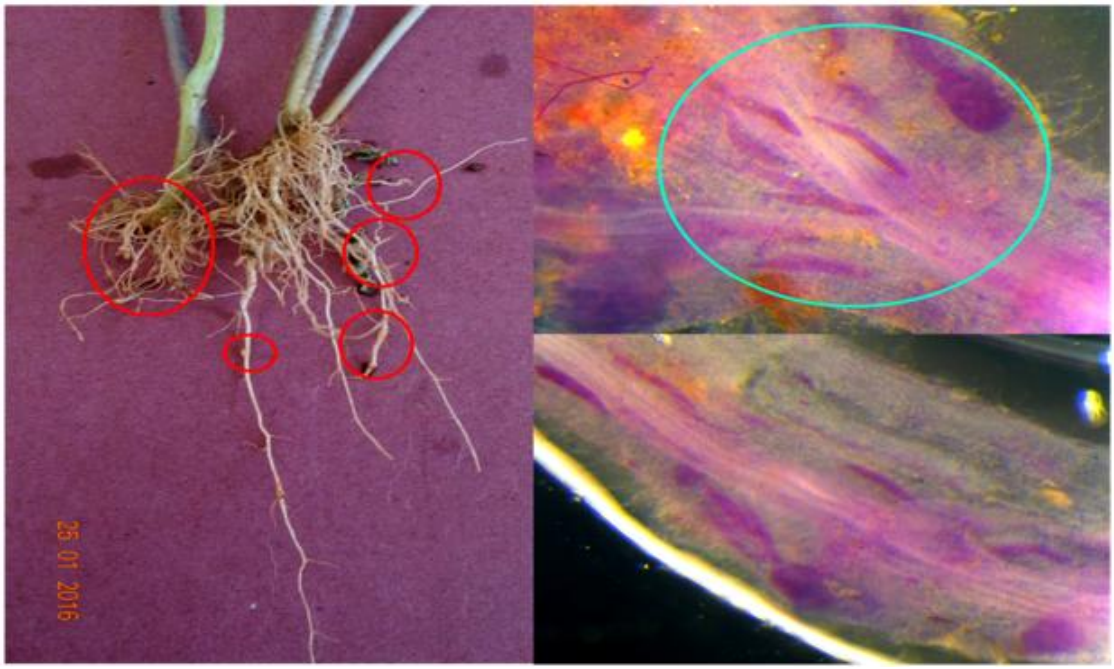

Plate 4: Galls on North Carolina tomato *cv. Rutgers* R J3 stages embedded in stained tomato galled root

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