Indian Journal of Agricultural Sciences **93** (3): 321–324, March 2023/Short Communication
https://doi.org/10.56093/ijas.v93i3.132216

Discerning host plant resistance sources in common bean (*Phaseolus vulgaris*) against root-knot nematode (*Meloidogyne javanica*) infection

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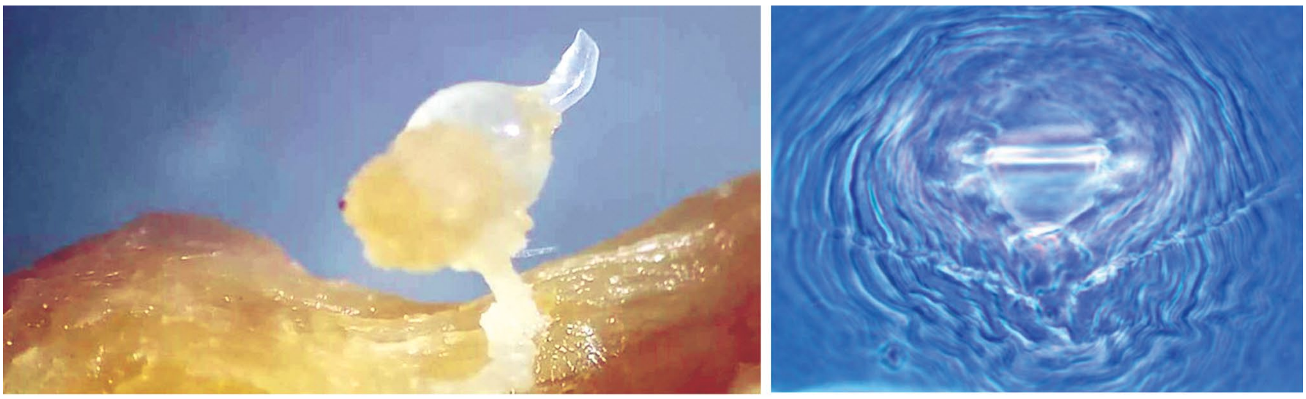
Received: 12 January 2023; Accepted: 01 February 2023

Keywords: Cultivars, Host plant resistance, *Meloidogyne javanica*, *Phaseolus vulgaris*

The common bean (*Phaseolus vulgaris* L.) is popularly called rajmash, a vital pulse crop with high yielding ability compared to gram and pea. According to FAOSTAT (2020), the common bean's global area was 34.80 million ha, and production was 27.54 million tonnes. Asia shares 43.1% of the worldwide production of common bean, followed by America (29.4%) and Africa (25.7%). In India, it is mainly grown in Maharashtra, Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir, and the north-eastern states. This crop is highly vulnerable to many biotic stress factors that limit bean production. Among the biotic stress, the root-knot nematodes (*Meloidogyne* sp.) are economically significant that cause crop losses in temperate, subtropical, and tropical climates (Perry *et al*. 2009). According to Baida *et al*. (2011) reports, *Meloidogyne* species can cause up to 90% yield loss of bean especially in high-temperature regions (Pedrosa *et al*. 2000). However, host plant resistance is one of the major components in Integrated Pest Management (IPM) which is environmental friendly, sustainable and socially adaptable (Jindal *et al.* 2007). Resistance to *Meloidogyne* sp. has been reported in several herbaceous, woody plants, annual and perennial crops in tropical and temperate regions (Cook and Starr 2006). The relationship between the root-knot nematode and host is genetically regulated in both organisms and host plant, has resulted in the evolution of the resistance genes in many crop species (Sidhu and Webster 1981). Using the nematode-resistant plant cultivar per genotypes is the best approach for economical and environmentally safe ways to minimise the yield loss caused by nematodes (Fassulliotis 1979). The identification of bean genotypes with some degree of resistance has been frequently reported in the literature (Silva *et al*. 2005). Such genotypes become important source of resistance to be used in breeding programs. Hence, resistance sources against *M. javanica* need to be identified, measured, and quantified to produce new cultivars that can keep the pest population below the economic threshold level. Therefore, the present study was carried out with the objective to identify resistance sources of common bean cultivars per genotypes accessions against *M. javanica* infection.



A, Female nematode attached to root   B, Female nematode perineal structure

Fig 1 Female nematode (A) and perineal pattern (B) of *M. javanica* (100x magnification).

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Table 1 Common bean cultivars utilized in the study

Cultivar	Biological status	Growth habit	Desired trait
Arun	Grain purpose	Semi-determinate	Tolerance to BCMVdisease
Uday	Grain purpose	Determinate	Wide adaptability
Amber	Grain purpose	Determinate	Tolerance to BCMVdisease
Utkarsh	Grain purpose	Semi-determinate	Tolerance to BCMVdisease
HUR15	Grain purpose	Determinate	Early maturing
HUR137	Grain purpose	Semi-determinate	Attractive seed color
Gujarat Rajamash	Grain purpose	Determinate	Attractive seed color
Arka Bold	Vegetable type	Determinate	Tolerance to BCMVdisease
Arka Komal	Vegetable type	Determinate	Pencil shape pod
Arka Anoop	Vegetable type	Determinate	High pods per plant
IVFB1	Vegetable type	Determinate	Long pod type
HPR35	Grain purpose	Determinate	Resistant to Anthracnose disease
HUR203	Grain purpose	Determinate	High pods per plant
Arka Suvidha	Vegetable type	Determinate	High pods per plant
Triloki	Vegetable type	Determinate	Attractive seed color

BCMV, Bean common mosaic virus.

Root-knot Nematode culture: The root knot nematode culture (*M. javanica*) was maintained at greenhouse, Division of Crop Protection, ICAR-Indian Institute of Pulses Research, Kanpur and the *M. javanica* species was identified based on the perineal pattern structure (Fig 1) of female nematode (Taylor *et al*. 1955). The population of the test nematode was developed from a single egg mass as per the protocol (Khan 2008), well ahead of the beginning of the experiment. After two months of inoculation on brinjal plant, the pure culture of nematode has been used for the experiment.

Experiment material: Total of 15 common bean cultivars comprising of nine-grain purpose bean varieties and six vegetable varieties were utilized in the study for evaluation against root-knot nematode. These experiment materials were collected from the Crop Improvement Division, ICAR-Indian Institute of Pulses Research, Kanpur, through proper means (Table 1).

Experimental layout: The fertile sandy loam soil was autoclaved at 15 kg/cm^2 pressure at 121ºC for 30 min and mixed with nematode culture contained soil and the inoculation was maintained at the rate of 2 infective juveniles (J_2s) per cc soil. It was then filled in PVC pipes (10 cm diameter and 30 cm length), which were inserted into the soil for maintaining natural soil temperature for the nematode infection. Common bean seeds were then sown at the research farm of Division of Crop Protection, ICAR-Indian Institute of Pulses Research, Kanpur in the pipes in 3 replications during 2021–22. Ninety days after sowing, the plants were uprooted and roots were washed under running tap water to remove soil particles from roots and examined for nematode infection and root galling.

Statistical analysis: The J2s of *M. javanica* were extracted from the soil of each pipe after uprooting the plants by using Cobb's decanting and sieving method followed by Baerman funnel technique (Southey 1986) to determine the soil population of nematodes. Gall index 0–5 scale (Table 2) has been calculated based on Taylor and Sasser (1978) standard protocol. The statistical data were analysed on egg mass, gall index, nematode final population and reproduction factors in completely randomised design using Web-based Agricultural Statistics Package (WASP, version 2. 0).

Table 2 Scale for the presence of root-knot nematode galls or egg masses on roots

No. of galls/plant	Gall index	Resistant rating
0	0	Immune (I)
1 – 2	1	Resistant (R)
3 – 10	2	Moderately resistant (MR)
11 – 30	3	Moderately susceptible (MS)
31 – 100	4	Susceptible (S)
100 +	5	Highly susceptible (HS)

Source: Taylor and Sasser (1978).

The host plant resistance classification of common bean cultivars against *M. javanica* race infection is given in Table 3. Results showed that no cultivar was classified as highly resistant or immune. The present study on the comparative screening of common bean accessions under controlled condition against *M. javanica* revealed significant variations among the genotypes in terms of root gall numbers, egg mass, reproduction factors of nematodes on the host. Among the screened varieties of common bean, Gujarat Rajmash, Amber (IPR 96-4) and HUR15 were classified under moderately resistant groups, hence proved to be moderately resistant as these cultivars allowed reproduction of the nematode but minimal root damage was recorded in terms of gall index. Sobczak *et al*. (2005) reported that, formation of fewer root galls in resistant to

Table 3 Reaction of common bean cultivars against *M. javanica*

Genotype	No. of egg mass/ plant	No. of galls/ plant	Gall Index	Reproduction factor	Degree of resistance
Arun	35.7	55.5	4	1.5334	Susceptible (S)
Uday	38.5	50.5	4	1.8	Susceptible (S)
Amber	18.5	10	2	0.56	Moderately resistant (MR)
Utkarsh	50.8	87.75	4	1.2	Susceptible (S)
HUR15	5.4	10	2	0.4	Moderately resistant (MR)
HUR137	10	30	3	1.6	Moderately susceptible (MS)
Gujarat Rajamas	10.5	10	3	0.95	Moderately resistant (MR)
Arka bold	15	25	3	1.3334	Moderately susceptible (MS)
Arka komal	37.2	47	4	1.1334	Susceptible (S)
Arka anoop	20	25	3	1.86	Moderately susceptible (MS)
IVFB1	50.7	65	4	1.6	Susceptible (S)
HPR35	30.5	35.75	4	1.6	Susceptible (S)
HUR203	60.7	92.5	4	1.2666	Susceptible (S)
Arka Suvidha	48.5	51.5	4	1.4666	Susceptible (S)
Triloki	30.5	37.75	4	1.7334	Susceptible (S)
CD (5%)	0.86	0.65			
CV	1.68	0.93			

moderately resistant cultivars were probably due to failure of the nematode infective juveniles to produce functional feeding sites in the host after invasion and to develop subsequently as reproducing females because of biochemical mechanism of invasion supporting this, which occurs due to non-cooperative action of host cell. The chemical inhibitors in the host tissue counteract or neutralize the giant cell inducing effect of salivary secretions of the nematode (Barrons 1939). The cultivars, viz. Triloki, Uday, Arun, and HPR35 were found moderately susceptible and eight cultivars, viz. Utkarsh, HUR137, Arka bold, Arka komal, Arka anoop, IVFB1, HUR203 and Arka suvidha exhibited susceptibility against *M. javanica* infection (Table 3). The host plant resistance reactions of these cultivars of common bean suggest that, resistance genes to the *M. javanica* were differing among the common bean cultivars. Therefore, common bean genotypes with resistance to *M. javanica* should be purified before using as sources of resistance in bean improvement program. Nevertheless, host plant resistance would be best served to select resistant genotypes based on root knot gall index in preliminary evaluation. However, selections based on nematode reproduction in advanced evaluation is desirable to confirm the stability of resistance and use in intergeneric hybridization program to understand the resistance mechanisms and the genetic basis for each genotypes. Thus, breeding programs for development of high-yielding common bean cultivars with tolerance to *M. javanica* should be encouraged to reduce losses in bean productivity and production.

SUMMARY

From this study we could conclude that, resistant cultivars are the single effective solution to the management of root-knot nematode population to avoid crop losses. Also, it is essential to use resistant cultivars in situations where nematodes are present and when control is advantageous to yields. However, the reported moderately resistant cultivars, viz. Gujarat Rajmash, Amber (IPR 96-4) and HUR15 belong to secondary gene pool with cross-compatibility to cultivated common bean. Therefore, it may be further used in the pre-breeding programme for developing resistant common bean cultivars against root knot nematodes.

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