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Research Paper

Standardization of planting time of *Tagetes spp.* for protection against nematode.

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ABSTRACT
*The present investigation entitled, "**Standardization of planting time of Tagetes spp. for protection against nematode**" was undertaken in the field of Insectary premises of Entomology Section, College of Agriculture, Nagpur. Rootknot nematode infest wide range of host primarily on tomato. It causes galls on roots as below ground symptom and dwarf, stunted growth with smaller yellowish foliage as above ground symptoms. Management of rootknot nematode by use of antagonistic plant like marigold instead of using chemicals is eco-friendly approach. Hence, this experiment was conducted for standardization of planting time of Tagetes spp. for protection against rootknot nematode.*
Among different planting time of Tagetes spp. and tomato, 2nd treatment found to be superior than other treatments where transplanting of one week old tomato seedlings were done after a week of transplantation of one week old marigold seedling resulted in significant reduction in number of tomato root galls (1.5 / plant), root (17.98 / 1.5 galls) and soil nematode population (27.95 / 50 ml) with a remarkable growth of tomato plant (32.20 cm) and minimum root gall index (1) compared to other treatments.
Considering the Eco-friendliness, it can be stated that the planting of antagonistic plant like French marigold Tagetes patula before the planting of tomato plant at a optimum spacing of 8 cm instead of chemical nematicides effectively reduces the root galls and nematode multiplication with healthy plant growth. Hence, the strategy can be included in nematode management without any adverse effect on agroecosystem.

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I. INTRODUCTION

Tomato (*Solanumlycopersicum* L.) is the most popular vegetable grown in the world, ranks second after potato but tops in the list of canned vegetables. It ranks third in priority after Potato and Onion in India. In India, Tomato is grown over an area of 852 thousand ha, with an annual production of about 21003 thousand metric tonnes with the productivity of 21.24 metric tonnes/ha. The major Tomato producing States in the country are Andhra Pradesh, Madhya Pradesh, Karnataka, Gujarat, Odisha, West Bengal, Maharashtra, Chhattisgarh, Bihar, Telangana , Uttar Pradesh, Haryana and Tamil Nadu. These States are account for 91% of the total production of the country. Maharashtra stands 7th having an area of 43.51 ha with a production of 362.31 thousand metric tonnes. with productivity of 24 metric tonnes/ha. (Anonymous, 2021).

The crop is attacked by various insect and non insect pests. In addition to insect pest and diseases, plant parasitic nematodes have also become a limiting factor in the successful cultivation of tomato.

Among different type of nematodes, rootknot nematodes (*Meloidogyne spp.*) are one of the most widely spread nematode pests parasitizing almost all the crops, grown all over the world. There are more than 90 described species in the genus *Meloidogyne* but the four most commonly occurring species are *Meloidogyne incognita*, *M. javanica*, *M. arenaria* and *M. hapla* (Sasser and Taylor, 1978; Karssen, 2000; Hunt et al., 2005). Among most common species of rootknot nematode, *Meloidogyne incognita*, is extremely polyphagous and attacks numerous economically important agricultural crops worldwide. But, most preferred hosts are vegetables, pulses, fibre crops, fruits and plantation crops. The rootknot nematodes,*Meloidogyne spp*., are basically parasites of roots and cause root galls or knots as a below ground symptoms.

Use of antagonistic plants for nematode management is a ecological approach. Among these plants, marigold (*Tagetes spp*.) is used for its nematicidal properties against plant-parasitic nematodes. Marigold can suppress 14 genera of plant-parasitic nematodes, with lesion nematodes (*Pratylenchus sp*.) and rootknot nematodes (*Meloidogyne spp*.) as the most affected one (Suatmadji, 1969). The marigold species most often used for nematode control are *Tagetes patula*, *T. erecta*, and *T. minuta*. The key mode by which marigolds suppress plant-parasitic nematodes is through a biochemical interaction known as allelopathy. Allelopathy is a phenomenon where a plant releases compounds that are toxic to other plants, microorganisms, or other organisms, such as nematodes. Marigold plants produce a number of potentially bioactive compounds, among which α-therthienyl is recognized as one of the most toxic. This sulfur containing compound is abundant in marigold tissues, including roots. It has nematicidal, insecticidal, fungicidal, antiviral and cytotoxic activities. It is believed to be the main compound responsible for the nematicidal activity of marigold. Thus nematodes may be killed either by entering the root system of a marigold plant or contacting soil containing marigold's bioactive compounds (Ploeg, 2007).

Detailed insight study about using different *Tagetes spp.*, at different planting time will help in most effective and ecological control measure against rootknot nematode *Meloidogyne incognita* of tomato.

By using marigold cultivars with their different planting time, we can judge effectively which cultivar, time of planting is effective against rootknot nematode and which is superior.

II. MATERIAL AND METHODS

For conducting these studies, tomato seeds, *Tagetes spp.* seeds of different varieties, earthen pots, polythene bags, labels, threads, rubber bands, tags, bamboo sticks, marker pen, plastic trays, hand gloves, beakers, measuring cylinder etc. were utilized for conducting the experiment and all these material were made available by Entomology section, College of Agriculture, Nagpur.

Experimental details:

1. Name of crop : Tomato (*Solanum lycopersicum*) and *Tagetes spp.*
2. Family : Tomato - Solanaceae

Tagetes spp. - Asteraceae

3. Variety : Tomato variety - S. 22

*Tagetes spp.*6 varieties -

1)*T. erecta* (African / American marigold),
2) *T. patula* (French marigold),
3) *T. species* Marigold Gulzafri Yellow,
4) Marigold Gulzafri Orange,
5) Marigold Dhan Basanti,
6) Marigold Hawaii Orange.

Time of sowing

i)Experimental Design : CompletelyRandomized Design (CRD)
ii) No. of Treatments : Four (4)
iii) No. of Replications : Six (6)

Table 1. Treatment details of experiment, "Standardization of plating time of *Tagetes spp.* for protection against nematode"

Treatment No.	Date Of Sowing	Treatment Details
T1	23/09/2017	Sowing of both *Tagetes spp.* and tomato seeds
T2	09/10/2017	One week old *Tagetes spp.* planted and after one week, transplanting of one week old tomato seedling
T3	09/10/2017	Transplanting one week old seedling of both *Tagetes spp.* and tomato
T4	09/10/2017	One week old tomato seedling planted and after one week, transplanting of one week old *Tagetes spp.* seedlings

The care was taken right from sowing till harvest of the experiments. Plants in the pots were watered 1-3 times daily depending upon the temperature and rainfall. Weeding was done timely to avoid weeds and to maintain proper growth of plants. Pots were randomly rotated to eliminate the effects of sun and shades.

Standardization of planting time of *Tagetes spp.* for protection against nematode.

This experiment was conducted in completely randomized design with four treatments replicated six times. African marigold *Tagetes erecta* was used for control of rootknot nematode. In first treatment sowing

of*Tagetes* seeds along with tomato seeds at 5 cm distance was done in the pots with nematode infected soil.In second treatment seedlings of one week old *Tagetes spp.*planted and after one week, transplanted one week old tomato seedlings 5 cm apart in the pots.In third treatment one week old seedlings of both *Tagetes* and tomato were transplanted 5 cm apart in the pot filled with nematode infected soil.In fourth treatment initially one week old tomato seedlings was planted and after one week, one week old *Tagetes* seedlings were planted. Weekly observation was taken on height of each plant for all the treatments.

After 60 days, each plant was uprooted carefully from soil. The roots were retrieved and kept in a basin of water to clear it from adhering soil particles and recorded the observations on plant growth characteristic (Shoot length), also on nematode multiplication such as number of galls, number of juveniles/plant roots and number of J2/100cc of soil. Roots were spread in big sized petriplate which contained water and recorded the observations on number of galls with the help of the hand lens. Extraction of nematodes for the count of number of juveniles/plants and number of J2/100cc of soil was done with Cobb's Sieving and Decanting method. The extracted nematodes per ml nematode suspension were counted under stereoscopic binocular microscope with the help of counting dish. The root gall index was calculated from observed number of root galls (Taylor and Sasser, 1978). It is based on scale of 0 to 5, where 0 = no galls; 1 = 1 to 2; 2 = 3 to 10; 3 = 11 to 30; 4 = 31 to 100; and 5 = more than 100 galls.

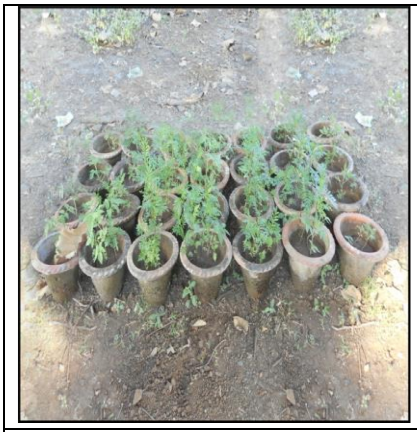

Plate No. 1: View of experimental pots for "Standardization of planting time"

Plate No. 2 : Depotting of plant after 60 days of transplanting

Plate No. 3 : Tomato sample kept for root washing

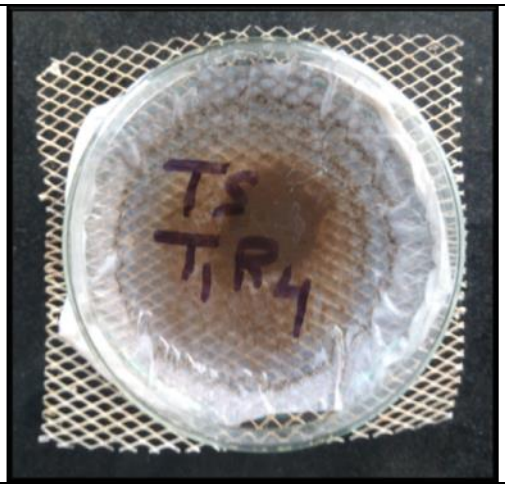

Plate No. 4 : Petriplates kept for extraction of rootknot nematode *Meloidogyne incognita* from soil and tomato roots

Statistical Analysis

The data obtained in respect of nematode population in CRD design was transformed into square root value as per Gomez and Gomez, (1984) and then subjected to statistical analysis to the level of significance of treatment.

III. RESULT AND DISCUSSION

The effect of different planting time of *Tagetes spp* and tomato on the reproduction factors of *Meloidogyne incognita* and plant growth parameter by standardization was studied in this experiment. Observations on nematode reproduction (number of galls/plant, numbers of nematodes in root/plant, soil nematode population and gall index) and plant growth parameter i.e. height of tomato plant before depotting were recorded.

Nematodes Reproduction factors

Number of galls per plant

Results in table 2 and figure 1 showed that the number of galls produced by *Meloidogyne incognita* on tomato were reduced significantly when it was planted with marigold simultaneously and alternately. The minimum number of galls per plant were recorded in 2nd treatment (1.5) where planting of one week old marigold *Tagetes erecta* was followed by one week old tomatoafter a week. It was statistically at par with 3rd treatment (3.50) where planting of both one week old *Tagetes* and tomato seedlings were done simultaneously.

Number of nematodes per plant root

Data in table 2 and figure 2 revealed that number of nematode population in plant root of tomato were reduced significantly when grown with marigold at different planting time. The minimum number of nematode population in tomato roots were recorded in in 2nd treatment (17.983) where planting of one week old marigold *Tagetes erecta* was followed by one week old tomato after a week. It was followed by 3rd treatment (21.10) where one week old both *Tagetes spp*. and tomato seedlings were planted simultaneously.

Soil nematode population per 100cc

Data presented in table 2 and figure 2 revealed that the soil nematode population at harvest was found significantly lower with different planting time of *Tagetes erecta* and tomato. The minimum nematode population (27.950) was observed in 2nd treatment where planting of one week old marigold *Tagetes erecta* was followed by one week old tomato after a week. It was at par with 3rd treatment (46.433) where one week both marigold *Tagetes erecta* and tomato seedlings were planted simultaneously.

Gall index

Perusal of data in table 2 and figure 4 revealed that gall index was significantly reduced with standardization of planting time of *Tagetes erecta* and tomato. The minimum gall index was recorded with 2nd treatment (1) where planting of one week old marigold *Tagetes erecta* was followed by one week old tomato after a week as compared to other treatments.

Plant Growth Parameter

Plant height

Data presented in Table 2 and figure 3 showed that the plant height was different in each treatment. Tomato grown with marigold with standardized time showed significant increase in the height of tomato plant. Among them, maximum plant height was found in 2nd treatment (32.20 cm) where planting of one week old marigold *Tagetes erecta* was followed by one week old tomato after a week. Minimum plant height was recorded in 1st treatment (23.60 cm) where seeds of both *Tagetes erecta* and tomato was planted at a same time.

Table 2.Effect of standardization of planting time of *Tagetes spp.* for protection against nematode (Average of six replicates)

Treatment (Planting of)	(a) No. of galls	(b) Roots nematode count	(c) Nematode population/100 cc soil	Total population (b+c)	Plant height (cm)	Gall index
T1 (*Tagetes* + Tomato seed)	6.00 (2.54)	25.75 (5.12)	49.317 (7.05)	75.067 (8.69)	23.60	1.83
T2 (1 wk old *Tagetes* + after 1wk, 1wk old tomato	1.5 (1.41)	17.983 (4.29)	27.950 (5.33)	45.933 (6.81)	32.20	1
T3 (1 wk old both *Tagetes* + Tomato)	3.500 (2)	21.100 (4.64)	46.433 (6.85)	67.533 (8.24)	28.83	1.66
T4 (1 wk old Tomato + after 1wk, 1wk old *Tagetes*)	5.833 (2.51)	29.150 (5.44)	84.283 (9.20)	113.433 (10.67)	24.5	1.83
S.Ed.	0.47	0.85	2.05			
$CD_{0.05}$	0.98	1.79	4.28			

(Figures in parentheses are $\sqrt{x+0.5}$ values)

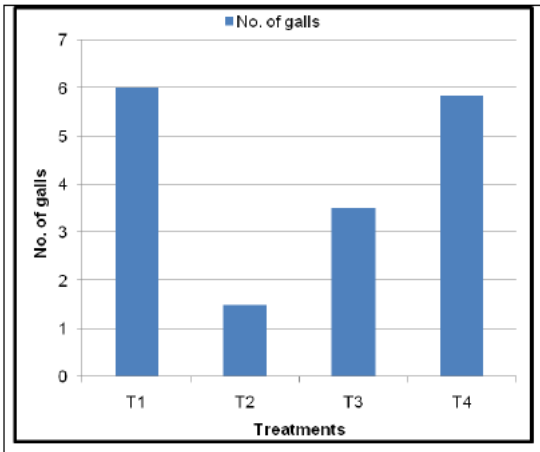

Fig. 1. Number of galls on tomato root

T_1 - Sowing of both *Tagetes spp.* and tomato seeds

T_2 - One week old *Tagetes spp.* planted and after one week, transplanted one week old tomato seedling

T_3 - Transplanting one week old seedling of both *Tagetes spp.* and tomato

T_4 - One week old tomato seedling planted and after one week, transplanted one week old *Tagetes spp.* seedlings

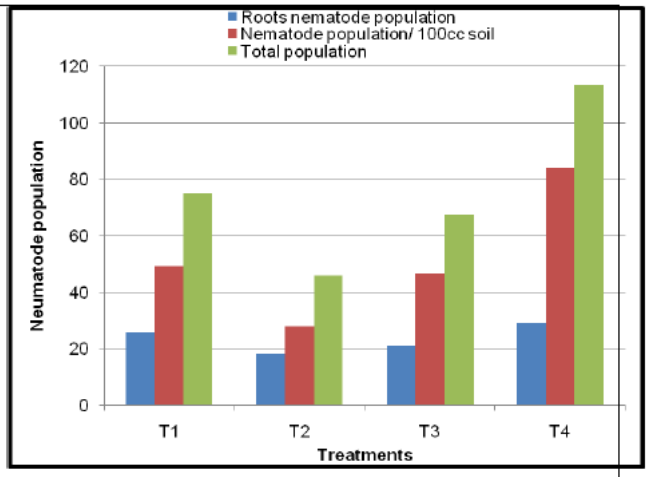

Fig. 2. Nematode population in tomato roots and soil

T_1 - Sowing of both *Tagetes spp.* and tomato seeds

T_2 - One week old *Tagetes spp.* planted and after one week, transplanted one week old tomato seedling

T_3 - Transplanting one week old seedling of both *Tagetes spp.* and tomato

T_4 - One week old tomato seedling planted and after one week, transplanted one week old *Tagetes spp.* seedlings

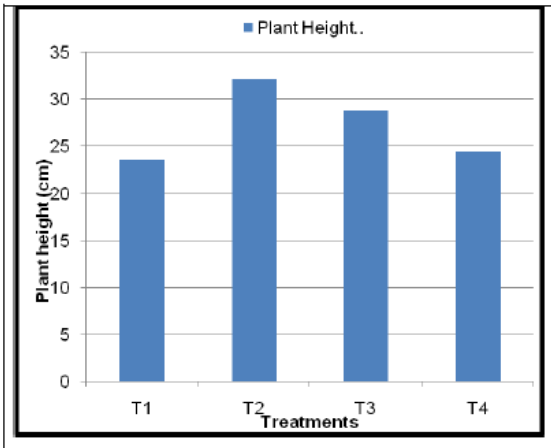

Fig. 3. Tomato plant height after 60 days of planting

T_1 - Sowing of both *Tagetes spp.* and tomato seeds
T_2 - One week old *Tagetes spp.* planted and after one week, transplanted one week old tomato seedling
T_3 - Transplanting one week old seedling of both *Tagetes spp.* and tomato
T_4 - One week old tomato seedling planted and after one week, transplanted one week old *Tagetes spp.* seedlings

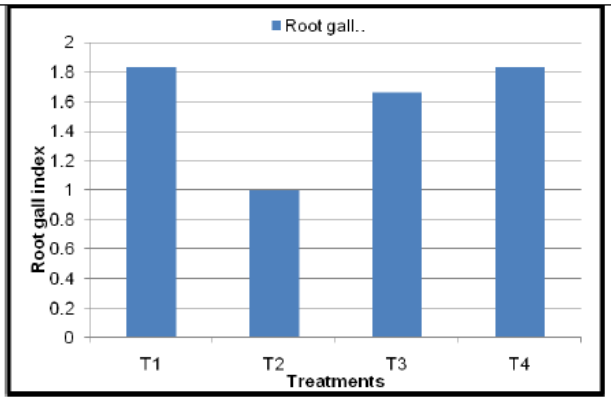

Fig. 4. Tomato root gall index

T_1 - Sowing of both *Tagetes spp.* and tomato seeds
T_2 - One week old *Tagetes spp.* planted and after one week, transplanted one week old tomato seedling
T_3 - Transplanting one week old seedling of both *Tagetes spp.* and tomato
T_4 - One week old tomato seedling planted and after one week, transplanted one week old *Tagetes spp.* seedlings

From the evident of the data recorded in the table 2, it is found that transplanting of one week old tomato seedling after a week of one week old marigold *Tagetes erecta* seedlings transplantation resulted in significant reduction in number of tomato root galls, root and soil nematode population with a remarkable growth of tomato plant and minimum root gall index compared to other treatments. 2nd treatment found to be superior than other treatments. These results are in conformity with the finding of Swamy et al. (1995) who observed that nursery beds previously planted with marigold gave maximum reduction in root-knot nematode population in soil and increased germination of seeds and production of more healthy tomato seedlings. Evenhuis et al. (2004) achieved better control of lesion nematodes (*P. penetrans*) in strawberry after marigold cv. Single Gold than after fumigation with 750 l/ha of metam sodium. Strawberry yields and fruit quality were also significantly greater following marigold.

Reynolds et al. (2000) compared *T. patula* and *T. erecta* as rotation crops with the traditional practice of growing a rye (*Secale cereale*) rotation crop plus chemical fumigation before transplanting flue cured tobacco (*Nicotiana tabacum*) in a field trial. Marigolds reduced *P. penetrans* population densities below the economic threshold for the cash crop for 3 years and increased tobacco yield by 197 kg/ha compared with rye plus chemical fumigation. Similarly, Seigies and Pritts (2006) found that rotating *T. erecta* with strawberry lowered nematodes to below detection levels and resulted in high root vigor and moderate fruit production. Marketable yield of carrot (*Daucus carota*) was higher in plots previously planted with *T. patula* cv. Happy Days than in those planted with corn or okra (*Abelmoschus esculentus*) and the number and weight of carrots with rootknot nematode galls following marigolds were lower (Huang, 1984).

Ploeg (2001) observed that nematodes have the greatest impact on crop productivity when they attack the roots of seedlings immediately after seed germination. According to Sikora and Fernandez (2005), the increase in the nematode populations and the subsequent reduction in the growth and yield of crops are directly influenced by the initial density of the nematodes in the soil. According to Ali et al.(1995) *Tagetes* species were more effective in reducing damage by *Meloidogyne* species on tomato roots than carbofuran. The possible explanations for the effectiveness of marigold in the management of root-knot nematode could be secretion of toxin a terthienyl and derivatives of bithienyle that kill the nematodes (Uhlenbroek and Bijloo, 1957).

IV. CONCLUSION

Considering the Eco-friendliness, it can be concluded that the planting of antagonistic plant like French marigold *Tagetes patula* before the planting of tomato plant at a optimum spacing of 8 cm instead of chemical nematicides effectively reduces the root galls and nematode multiplication with healthy plant growth. Hence these various strategies can be included in nematode management without any adverse effect on agroecosystem.

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