I. INTRODUCTION
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Tobacco (*Nicotiana tabacum* L.) is one of the important commercial crops of India. According to one source, tobacco was in existence in Asia even during the 12th century, when it was not known elsewhere. It was not only used as an intoxicant but also as a cure for all kinds of ills and paying homage to deities. Tobacco is said to have been introduced into India in the beginning of 17th century. As elsewhere in the world, it has thrived despite its considerable neglect and social disapproval (Gopalachari, N.C., 1984).

The genus *Nicotiana* is one of the five large genera of solanaceae and is represented by about 60 recognized species which are grouped in three sub groups

Viz.,: Sub genus – rustica,

Sub genus – tabacum

and Sub genus – Petuniodes.

Out of the 60 species, only two species ie., *Nicotiana tabacum* and *Nicotiana rustica* are cultivated extensively. India grows both the species, but by far the largest area is under *Nicotiana tabacum* which is grown all over the country. Since
*N. rustica* requires cooler climate, its cultivation is confined mainly to the northern and north eastern areas of the country i.e., Punjab, U.P., West Bengal, Bihar and Assam.

The *Nicotiana tabacum* varieties known as desi types have tall plants with broad leaves and have usually pink flowers. The *N. rustica* varieties known as vilayati and culcuttia are characterized by short plants with round puckered leaf and yellow flowers. Specific varieties in *Nicotiana tabacum* have been developed for cigarette, cigar and cheroot, bidi, hookah and snuff tobaccos. The varieties developed in *N. rustica* are used for only chewing, hookah and snuff tobaccos.

Unlike in other crops, in tobacco, the ultimate product is the leaf that is consumed. Nicotine is the principal alkaloid present in tobacco leaf. Large quantities of tobacco are consumed for smoking, chewing and snuff. Small quantities are also utilized in the manufacture of nicotine sulphate used as insecticide and for pharmaceutical purposes.

Tobacco is consumed in one form or the other all over the world and possibly it is the most democratic luxury and as such it is a rich man’s solace and poor man’s comfort (Plate-1). With
the ever changing socio economic conditions and mounting
tensions associated with the present day living, consumption of
tobacco as a means of relaxation has increased considerably
(Plate-2). The trends in tobacco consumption in recent years
show more preference towards smoking than other forms.
Tobacco is grown in an area of 0.4 million ha (0.23% of the total
arable land) producing 595 million kgs of tobacco. India
produces almost all types of tobacco and Flue Cured Virginia
(FCV) and Burley tobacco are the main exportable types. The
production of FCV tobacco is about 200 m.kgs from an area of
0.15 m.ha. India earned Rs.1096 crores as foreign exchange and
Rs.9000 crores as excise duty during 2003; India occupies
second place in area and production accounting for about 10%
of worlds’ area and around 9% of tobacco production.

India is one of the leading exporters of tobacco, occupying
third place in overall exports of tobacco after Brazil and U.S.A.
The bulk of the exports (70-85%) continue to be FCV only. In
addition to this, other countries like, U.K., Germany, Belgium
and the erstwhile USSR are the major importers of Indian FCV
tobacco accounting for more than 60% of our exports. The
positive and significant features of Indian tobacco witnessed
lower levels of heavy metals, tobacco specific nitrosamines (TSNA) and pesticide residues compared to other tobacco producing countries.

Tobacco being a labour intensive crop, provides employment to a large number of people in the field as well as in the factories (Plate-3). For handling and processing the leaf during the season, over one million skilled and unskilled labourers are employed (Plate-4). Further, in the tobacco industry, right from the stage of leaf tobacco in the field to that of marketing of the end product, nearly 35 million people are provided with employment. Over six million farmers are earning their likely hood from this crop. Similarly, the bidi, the cigar and chewing and allied industries are also contributing their share towards better shape of the economy of our country.

In the economy of the country, a reference to tobacco product is appropriate. The product industry, more particularly the cigarette industry, has also been playing a major role. Currently, over Rs.9000 crores is earned by way of excise duty on the product industry (cigarettes) annually.

The tobacco leaf and products industries have been the feeders, besides bringing about a multiplier effect in respect of
many ancillary industries, viz., fertilizers, pesticides agricultural engineering machineries, curing barns, tobacco testing equipments, hessian and gunny cloth, fire wood, ply wood, Kraft papers, iron nails, binding wires jute twines, polythene, tinfoil, coal, power and associated works. Thus, Indian tobacco have been playing a tri-dimensional role in this regard by way of (1) Earning the much needed foreign exchange for various developmental activities (2) Fostering industrial development and (3) Providing sizable employment opportunities (Gopalachari, 1984).

The Southern Transition Zone of Karnataka is ideally suited for growing export quality of flue cured tobacco (FCV) (Fig.-1). It is grown mainly in parts of Shimoga, Chickmagalur, Davanagere, Hassan and Mysore districts. Karnataka produces FCV tobacco to the tune of 90.4 million kgs from an area of 73,900ha with a total production of 82.9 M. kgs during 2005-06. FCV tobacco from Karnataka is in great demand in the international market under the brand name “Mysore Style tobacco” FCV tobacco produced from Karnataka in the light soils is known to have very low TSNA (non detectable levels to 0.19 ppm) and pesticide residue well below the guidance residue levels.
Tobacco is an excellent source of phyto chemicals which can be converted into value added products beneficial to the mankind. *Solenasol* an ingredient of cardiac drug from tobacco leaf has been extracted which needs to be harnessed commercially. There are reports that tobacco seeds contain 36-40% of edible oil rich in poly unsaturated fatty acids. Nicotine sulfate extracted from tobacco leaf is known to be a good pesticide.

In Karnataka, tobacco crop grown in the light soils, provides ideal conditions for development and perpetuation of pathogens. Under favourable weather conditions, these become epidemic resulting in severe losses. There are innumerable diseases caused by fungi, bacteria, viruses, nematodes and the root parasite, orabanche affecting the yield and quality of tobacco both in the nurseries and field.

Apart from the diseases caused by other pathogens, it also suffers from the attack of plant parasitic nematodes both in nursery as well as transplanted crops and is one of the important constraints in crop production.

Different genera and species of plant parasitic nematodes are reported to be associated with tobacco crop and their
distribution is widespread covering all the tobacco growing states in the country. Hussaini (1986) reviewed the literature and briefed the work of various workers and recorded *Hoplolaimus angustalatus*, *Helicotylenchus erythrine*, *Tylenchorhynchus latus*, *Pratylenchus zeae*, *P thornei*, *Meloidogyne arenaria*, *Rotylenchulus reniformis*, *Trichodorus minar* on bidi tobacco in Gujarat; *H. erythrine*, *Pratylenchus* spp, *M arenaria*, *R reniformis*, *Longidorus* elongates on FCV and bidi tobacco in Hunsur (Karnataka).

*M javanica* was found infesting FCV tobacco in Andhra Pradesh *M incognita acrita* on hookah and wrapper tobacco in Pusa (Nagarajan 1975); *M incognita* and *M javanica* on bidi tobacco in Gujarat; *M incognita*, *M arenaria*, *M javanica* and *M thamesi* on FCV tobacco in Karnataka. *M incognita acrita* on hookah and wrapper tobaccos in Bihar. *Meloidogyne* spp are also known on tobacco in West Bengal (Mukhaerjee and Dasgupta, 1983).

Root-knot menace is increasing every year especially in tobacco nurseries, which are abandoned under severe infestation and new sites are taken up for raising seedlings. Infestation at early stage results in heavy loss in yield and quality of leaf.
Root-knot, a disease caused by root-knot nematodes *Meloidogyne incognita* (Kofoid and White, 1919; Chitwood, 1949) and *Meloidogyne javanica* (Treub, 1885; Chitwood, 1949) is a major production constraint in tobacco (Plate-5, 6, 7, 8, 9 and 10). Yield reduction due to root-knot nematode in FCV tobacco in both nursery and field crops was estimated to the tune of 59.4 per cent and 52.9 per cent respectively (Hussaini, 1983). Similarly, green and cured leaf yields are reduced by 29.6 per cent and 15.1 per cent respectively (Hussaini, 1983). Apart from causing damage on their own, they also involve with other pathogens like fungi, bacteria and viruses causing disease complexes which will be very difficult to manage.

*M incognita* and *M javanica* are widespread on tobacco, the latter being more resistant to drought and high temperatures. *M arenaria* and *M hapla* are less distributed and the latter is restricted to cooler areas. However, of late, *M arenaria* population is increasing because of crop rotation. In some localities, one or two species are predominant. In some cases, there are even mixtures of populations. With every tenfold increase in initial population, the yield loss increases by 3% in *M hapla*, 8-9% in *M incognita*, 16-17% in *M arenaria*, 19% in *M javanica*. In USA, upto 14% annual yield loss has been
estimated. In heavily infested soils, loss may be 25% in fields and 50% in nursery seedlings in India, 20-25% in Iraq, 50-60% in Turkey respectively (Dasgupta, 1998).

Infection of root-knot nematode commences in the nurseries as soon as seeds germinate. The diseased seedlings are stunted and unthrifty with sparse and shallow root system. The infected leaves become interveinally yellow, thin, scorched at tips with rim fire appearance and finally turn brown. Meanwhile wilting occurs during the day. Root-knot of tobacco typically occurs in patches in a field. In Karnataka, whole field may be affected simultaneously. Further, root galls are visible within 48 hours of infection, finally leading to crop failure. Nicotine content is much reduced in the leaves on the other hand. There is widespread potash deficiency in root-knot infested fields. The life cycle of root-knot nematode ranges from 21 days in summer to 56 days or more in winter (Fig.-11). Population of 5 juveniles/ml of soil is the pathogenic level have been recorded. Root-knot may attain 98% frequency with an index of 3.16 on 1-58 scale. Damage is more in light soils or peats and spread takes place through infected seedlings, contaminated implements, workers' feet, animals and irrigation water. However, survival may be easy on weed hosts but
Mjavanica could survive for 4 years on clean fallow after tobacco in Rhodesia. Leaves are most susceptible to brown spot (Alternaria tenuis), anthracnose (Colletotrichum tabacum), frog eye spot (Cercospora nicotianae) and powdery mildew (Erysiphe cichoraceasum) (Milne, 1972).

For the control of these nematodes, many effective nematicides are available. However, in recent years, majority of them have been withdrawn from the market because of health hazards to production workers and also due to their detection at unacceptable levels in ground water (Johnson and Feldmesser, 1987). Added to this, they are costly, not easily available and require sophisticated method of application have restricted their large scale adaptability.

On the other hand, there are few ecofriendly measures available for the management of this menace viz., soil solarization, organic amendments, botanical pesticides and screening of germplasm for resistance against nematodes.

**Soil Solarization**

In recent years a new method for controlling soil borne pathogens and weeds by means of solar heating of the soil was
developed in Israel (Katan et al., 1976). This practice has been used to control effectively *Verticillium* and *Fusarium* diseases in vegetables and *Verticillium dahliae* in *Pistacia* (Katan, 1981). This is also achieved by mulching the soil during the hot season with transparent polyethylene sheets thereby increasing soil temperature and controlling pathogens. Mulching has the advantages of being cheap, simple, non-hazardous, effective on targeted and other pathogens too and of eliminating the need for toxic materials. It also reduces pest and weed intensity, released certain plant nutrients and increased soil moisture accumulation (Horiuchi, 1984; Katan, 1981; Stapleton and Devay, 1983, 1986; Gaur and Perry 1991). This method is also known by different synonyms viz., solar heating, soil mulching, solar tarping and soil solarization.

The methodology has been used successfully to reduce population of plant parasitic nematodes, various plant pathogenic fungi and the weeds (Barbercheck et al., 1986; Katan et al., 1983). In India use of soil solarization in tobacco nurseries is of recent origin. Patel and Makwana (1992) in bidi tobacco and Hussaini et al. (1993) and Ravindra et al. (1997) in FCV tobacco have used the technique for the control of root-knot nematode in the nurseries.
However, there is no single method which is efficient / sufficient to keep the nematode population under control. Hence, there is a need to integrate available ecofriendly methods for the effective management of root-knot nematode.

A critical review of literature has revealed that no data are available pertaining to study on integration of ecofriendly methods for the nematode management. Hence, this study was undertaken during 2003 to 2005 to know the efficiency of soil solarization and bio pesticides against the control of root-knot nematode of tobacco.

1.1 Objectives of Study

The following objectives witness the study:-

1. To evaluate soil solarization in the management of root-knot nematode in nurseries.

2. Evaluation of certain indigenous botanical species along with soil solarization individually and in integration with soil solarization for the management of root-knot nematode.

3. To evaluate the efficacy of non edible oil cakes in integration with soil solarization individually and in integration with soil solarization for the management of root-knot nematode in nurseries.
4. To test the efficacy of poultry manure and sheep manure in integration with solarization for the management of root-knot nematode.

5. Screening of germplasm to identify sources of resistance / tolerance against root-knot nematode.
Fig. 1 FCV tobacco growing areas of Southern Transition Zone