VI. SUMMARY
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Tobacco is an important commercial crop of India with an area of about 4 lakh ha. Although leaf continues to be the economic part, some new industrial uses of tobacco have been envisaged as a strategy to sustain tobacco cultivation, especially in view of the tobacco related health problems. Tobacco seed is a rich source of nicotine free seed oil.

In Karnataka, tobacco crop is being cultivated in light soils which provide an ideal conditions for development and perpetuation of root-knot nematodes. Root-knot nematodes are a major threat for the successful cultivation of tobacco. It is a menace both in nursery and main field.

There are few nematicides available for the control of nematodes. However, they are not being used by the farmers because of their high cost, non availability, phytotoxicity, health hazards to field workers and pollution to environment.

Nematode management is obligation for successful production of tobacco of different types. Hence, an attempt was made to evaluate the ecofriendly manures like soil solarization,
amendment with organic cakes, poultry and sheep manure, botanical pesticides, screening of germplasm for resistance against nematodes and their suitable integration which are available for the control of nematodes.

**Soil Solarization**

### 6.1.1 Effect of Soil Solarization on Soil Temperature

Soil temperature increased in solarized beds over unsolarized beds depending on the soil depth. It was found considerably higher at the upper 5cm. depth while at 20cm. depth the temperature increase was fairly low the range of temperature increase varied from 4.0 to 39.9 per cent over that of unsolarized beds at 5cm. depth whereas it was only 1.0 to 6.8 per cent at 20cm. depth. As compared to unsolarized beds, the increase in temperature at 5cm. depth was 4.0 per cent in 2 weeks of solarization, 12.5 per cent in 4 weeks of solarization, 18.2 per cent in 6 weeks of solarization and 40.0 per cent in 8 weeks of solarization.

### 6.1.2 Effect of Soil Solarization on Seed Germination

There was no adverse effect of soil solarization on germination of the seed. The seed germination was excellent in all the solarized beds. It showed an increasing trend in seed
germination count from 71.67 in 4 weeks, 73.89 in 6 weeks to 84.44 in 8 week of solarization.

The germination was further improved in the treatment combination of soil solarization with carbofuran from 77.22 in 4 weeks, 78.89 in 6 weeks to maximum of 90 in 8 weeks.

6.1.3 Effects of Soil Solarization on Seedling Production at 60 Days

Soil solarization yielded significantly higher number of transplantable seedling compared to check. Production increased with the enhanced solarization periods from 4 to 8 weeks where it was 418.67, 460.89 and 594.4 seedlings in 4, 6 and 8 weeks respectively. Further, in the treatment combination of solarization plus carbofuran the seedling production considerably increased from 4 weeks to 8 weeks.

The treatment combination of solarization for 8 weeks along with carbofuran was significantly superior to all other treatments (786.11) followed by solarization alone for 8 weeks (594.44) which were significantly superior to the remaining treatments.
6.1.4 Effect of Soil Solarization on Seedling Production at 75 Days

The seedling production was in similar pattern which was observed at 60 days. All the solarized beds with or without carbofuran were significantly superior to the unsolarized beds. Seedling yield enhanced with prolonged solarization period from 4 weeks to 8 weeks. Soil solarization for 8 weeks with carbofuran (860.00) was significantly superior to rest of the treatments in seedling production followed by solarization alone for 8 weeks (695.33).

6.1.5 Effect of Soil Solarization on Total Transplantable Seedlings Production

The fact that solarization of nursery beds contribute to the increased production of seedlings was clearly evident as all the solarized beds with or without carbofuran were significantly superior to unsolarized beds in receiving significantly higher number of seedlings.

The enhanced effect of solarization on seedling production was clearly depicted in the form of significant availability of healthy transplantable seedlings in the solarized beds for 8 weeks with carbofuran (1294.55) followed by 8 weeks of
solarization alone (61138.78). In unsolarized beds there was no recovery in seedling availability (536.67).

6.1.6 Effect of Soil Solarization on Root-knot Nematode at 60 Days

The deleterious effect of increased temperature due to solarization on root-knot nematode was clearly noticed in the form of significantly minimized root-knot indices in solarized beds as compared to unsolarized beds.

Solarization of nursery beds for 8 weeks with (1.34) or without carbofuran (1.63) was significantly superior to rest of the treatments in reducing the root-knot index. Unsolarized beds recovered highest root-knot index (4.63).

6.1.7 Effect of Soil Solarization on Root-knot Nematode at 75 Days

The prolonged existence of seedlings up to 75 days in unsolarized beds resulted in multiple galling. The advantage of solarization of nursery beds was clearly proved as there was significantly minimum gall indices in the solarized beds as compared to unsolarized beds. The enhanced period of solarization up to 8 weeks with (1.37) or without carbofuran
(1.57) proved to be significantly superior treatments by recording lowest root-knot indices. Whereas, unsolarized beds exhibited maximum root-knot index (4.60).

6.1.8 Effect of Soil Solarization on Weeds

Soil solarization resulted in significant reduction of weeds in solarized beds as compared to unsolarized beds. The prolonged period of solarization upto 8 weeks with carbofuran had significantly deleterious effect on weeds (7.78) followed by 8 weeks of solarization (13.55) and 6 weeks of solarization plus carbofuran (21.00). Maximum weeds were noticed in unsolarized beds (176.67).

It was observed that though prolonged periods of soil solarization from 4 weeks to 8 weeks had significantly more beneficial effects on production of transplantable seedlings, enhanced nutritional availability to the plants thereby luxuriant growth and reduction in weeds and root-knot index, it was noticed that enhancement of solarization periods above 4 weeks was not practicable as the plastic film turned opaque, and brittle and not reusuable. Further, prevention of damage by wind and trampling by animals and workers is a serious problem. Hence, the solarization periods were reduced to 2 to 4 weeks and further
it was integrated either with botanical pesticides, oilcakes, or poultry manure etc., to obtain the same effect of enhanced solarization periods.

6.2.1 Effect of Integration of Botanicals and Soil Solarization on the Production of Transplantable Seedlings at 60 Days

All the individual botanical treatments and treatments having solarization component for 2 weeks were significantly superior to check. Soil solarization along with marigold leaves incorporated was significantly superior to rest of the treatments with maximum seedling production followed by solarization with neem leaves.

6.2.2 Effect of Integration of Botanicals and Solarization on Production of Transplantable Seedlings at 75 Days

Solarization with integration of neem leaves, marigold leaves, pongamea leaves and neem leaves alone were on par and significantly superior to rest of the treatments in yielding highest number of transplantable seedlings.

6.2.3 Effect of Integration of Botanicals and Soil Solarization on Root-knot Nematode at 60 Days

All the botanicals with or without solarization component were significantly superior to check in reducing the root-knot
index in transplantable seedlings. However, in corporation of marigold leaves along with solarization recorded least root-knot index.

6.2.4 Effect of Integration of Botanicals and Soil Solarization on Root-knot Nematode at 75 Days

The enhanced effect of solarization on the decomposition of botanicals was clearly evident as all botanicals singly and in combination with solarization significantly reduced the root-knot index in transplantable seedlings compared to unsolarized beds. However, neem leaves alone and marigold leaves in combination with solarization were significantly superior over rest of the treatments in minimizing the root-knot index in transplantable seedlings.

6.3.1 Effect of Integration of Oil Cakes and Poultry Manure with Soil Solarization on the Production of Transplantable Seedlings at 75 Days

Incorporation of neem cake, pongamea cake and poultry manure either solely or in combination with soil solarization yielded significantly highest number of transplantable seedlings compared to check. Soil solarization for 2 weeks in combination with either neem cake or poultry manure or carbofuron and soil
solarization for 4 weeks were significantly superior to rest of the treatments and on par with each other. However, solarization for 2 weeks plus neem cake recorded highest seedling production (422) followed by solarization alone for 4 weeks (395), solarization for 2 weeks plus poultry manure (390) and solarization for 2 weeks plus carbofuran (375).

6.3.2 Effect of Integration of Oil Cakes and Poultry Manure with Soil Solarization on Root-knot Nematode at 60 Days

The deleterious effects due to incorporation of neem cake, pongamea cake and poultry manure with or without soil solarization on root-knot nematode was clearly evident in the form of least root-knot indices. Soil solarization alone for 4 weeks, soil solarization for 2 weeks, soil solarization for 2 weeks plus poultry manure and soil solarization for 2 weeks along with pongamea cake plus carbofuran were significantly superior to the rest of the treatments and on par. Least root-knot index was noticed in solarization alone for 4 weeks (1.25) followed by solarization for 2 weeks alone (1.90), solarization for 2 weeks plus poultry manure (1.94) and solarization for 2 weeks along with pongamea cake plus carbofuran (1.95). Highest root-knot index was observed in the check (3.54).
6.3.3 Effect of Integration of Oil Cake and Poultry Manure with Soil Solarization on Root-knot Nematode at 75 Days

At 75 days, solarization for 4 weeks, solarization for 2 weeks with neem cake and solarization for 2 weeks plus poultry manure were found to be on par and significantly superior over the other treatments. Least root-knot index was recorded in soil solarization for 4 weeks (1.53) followed by solarization for 2 weeks plus neem cake (1.55) and solarization for 2 weeks with poultry manure (1.60). Maximum root-knot index of 4.50 was noticed in the check.

6.3.4 Effect of Integration of Oil Cakes and Poultry Manure with Soil Solarization on Surveillance of Weeds

All the treatments were significantly superior to check in reducing the weed intensity. Solarization for 4 weeks alone, solarization for 2 weeks alone, solarization for 2 weeks with neem cake, solarization for 2 weeks plus pongamea cake, poultry manure alone and solarization for 2 weeks plus poultry manure were on par and significantly superior to rest of the treatments. Solarization for 2 weeks plus neem cake recorded lowest weed intensity (22) followed by solarization for 4 weeks (25), solarization for 2 weeks alone (34), solarization for 2 weeks plus
pongamea cake (35), solarization for 2 weeks plus poultry manure (35) and poultry manure alone (40). Maximum weeds were noticed in the check (165).

6.4.1 Effect of Integration of Sheep and Poultry Manure with Soil Solarization on Transplantable Seedling Production at 60 Days

All the treatments were significantly superior to check. Poultry manure along with solarization for 4 weeks was significantly superior to other treatments in yielding highest number of transplantable seedlings. However, neem cake with solarization, sheep manure with solarization and poultry manure alone were on par and significantly superior to rest of the treatments. Highest number of seedlings were produced in solarized beds along with poultry manure (185) followed by solarized beds with neem cake (140) and poultry manure alone (96). Least number of seedlings were recorded in the check (60).

6.4.2 Effect of Integration of Sheep and Poultry Manure with Soil Solarization on Transplantable Seedling Production at 75 Days

The trend noticed at 60 days with respect to transplantable seedling production was repeated at 75 days wherein all the
treatments were significantly superior to check. Poultry manure with solarization for 4 weeks was significantly superior to other treatments in production of highest number of transplantable seedlings (210) followed by neem cake with solarization (170) and sheep manure with solarization (165) which were on par and significantly superior to rest of the treatments. Least number of seedlings were produced in the check (75).

6.4.3 Effect of Integration of Sheep and Poultry Manure with Soil Solarization on Root-knot Nematode at 60 Days

All the treatments were significantly superior to the check in reducing the root-knot index. Poultry manure with soil solarization (1.75) neem cake with soil solarization (2.00) and poultry manure alone (2.10) were on par and significantly superior to other treatments in restricting the root-knot index. Highest root-knot index was noticed in the check (3.25).

6.4.4 Effect of Integration of Sheep and Poultry Manure with Soil Solarization on Root-knot Nematode at 75 Days

The same trend observed at 60 days regarding the reduction of root-knot index was repeated at 75 days wherein all the treatments were significantly superior to the check. Poultry manure with soil solarization (2.40), neem cake with soil
solarization (2.50) and poultry manure alone (2.70) were significantly superior to rest of the treatments and were on par. Sheep manure with soil solarization recorded higher root-knot index (3.25) followed by solely carbofuran treated beds (3.20). Maximum root-knot index was observed in the check (4.00).

6.5.1 Screening of Germplasm for Resistance against Root-knot Nematode

A total of 111 breeding materials of FCV tobacco comprising germplasm, lines or varieties were subjected to screening against root-knot nematode. FCV special a susceptible variety to root-knot nematode was used as susceptible check. Screening of these breeding materials revealed different type of reactions against root-knot nematode which was reflected in the form of root-knot index recorded by them. A total of 32 entries viz., KST-17, KST-19 (Thrupti), KST-20, KST-21, KST-25, KST-28, Bhavya, JL-53-12, FCH-144, FCH-145, FCH-148, FCH-184, Bigorinica, Delcrust-P, 94-3-6-1-5-1, 95-1-3-6-4, 95/4, V-4080, II1624, ILTD Spl., V-4056, CM-12, Gold line, KGC-1, 1308, 86-4-1-1-1-9, 86-8-3-2-1, 1099/2/2, F-210, PCT-16, L-621 and CTRI Spl. MR x MDC-57 recorded root-knot index varying between 1 and 2 indicating that the disease intensity is very mild to mild thus they are highly resistant to root-knot nematode.
Resistant reaction to root-knot nematode was exhibited by 30 entries viz., KST-26, KST-27, CY-133, CY-135, JL-5-97, JL-19-96, JL-32-95, JL-52-78, JL-52-36, PCT-7, FCH-6523, FCH-164, FCH-194, Cocker-140, 95-3-1-2-5-1, 95-1-3-6-2-1, 95/3, V-4064, 48/54, II1623, Gold streak, NLS-4, 86-8-3-2-1-2, 86-8-3-2-1-3, 1294/4, 1117, L-1031, 1127, Black shank resistant, Bhavya x PCT-7 and Bhavaya x Delcrust which showed root-knot index varying between 2 to 3 with the disease intensity between mild to moderate.

Root-knot index varying from 3 to 4 was exhibited in the entries, KST-18, KST-29, Ratna, CY-139, CY-146, CY-118-5C-1, CY-142, FCH-154, FCH-172, FCH-187, FCH-188, VA-116, L-1358, L-1366, L-1359, 94-10-7-1-9-3, 95/5, V-3884, V-4076, II-1619, 1204/4, II-1308, V-3543, V-3643, 88-15-5-1-7, 88-15-5-1-4, Swarna, Kanakaprabha, MDC-57 and Bhavaya x MDC-57 indicating the disease intensity from moderate to severe. Thus, these 30 entries are found to be susceptible to the root-knot nematode. While, the entries viz., KST-22, KST-23, CY-149, JL-32-96, FCH-177, N-98, V-4219, 94-5-8-5-2-1, V-3703, 134/4, NLS-5, V-3571, 1099/214, 1099, 1117/2, 86-4-1-1-1-7, FCV-Special and Navile-1 registered root-knot index varying between 4 and 5 indicating the disease intensity from severe to very severe and therefore these 18 entries are highly susceptible.
6.5.2 Conclusions

Based on the research findings of the five different studies following conclusions are arrived at:

- Soil solarization of tobacco nursery beds is essential. It has no adverse effect on tobacco seed germination.

- Enhanced solarization periods from 4 to 8 weeks yields significantly highest number of transplantable seedlings with significantly least root-knot index. However, prolonged solarization duration from 4 to 8 weeks is not desirable as the LDPE sheets will become opaque, brittle and not reusable, besides getting exposed to damage by wind and trampling by animals and workers.

- Hence, attempts were made to reduce the duration of solarization period from 4 weeks to 2 weeks in integration with organic amendments and botanical pesticides.

- Two weeks of solarization of nursery beds in integration either with neem cake or poultry manure or marigold or neem leaves is equally effective as that of 4 weeks of solarization in getting significantly higher number of transplantable seedlings with significantly least root-knot index.

- Out of 111 germ plasm screened, 32 entries were found to be highly resistant to root-knot nematode. Among them
Thrupti (KST-19) and Bhavya are most popular varieties in Karnataka tobacco farmers. The other highly resistant lines are KST-17, KST-20, KST-21, KST-25, KST-28, JL-53-12, FCH-144, FCH-145, FCH-148, FCH-184, Bigorinica, Delcrust-P, 94-3-6-1-5-1, 95-1-3-6-4, 95/4, V-4080, II-1624, ILTD Spl., V-4056, CM-12, Gold line, KGC-1, 1308, 86-4-1-1-1-9, 86-8-3-2-1, 1099/2/2, F-210, PCT-16, L-621 and CTRI Spl. MR x MDC-57 which are promising for utilisation in resistant building programmes.

6.5.3 Future Line of Work

The following lines of research are suggested for future work. Interest in solarization arises because it is a fully integrated pest control method, based on easily manipulated physical factors.

Solarization can not only be a possible replacement for weedicide but is also an eventual solution for situation in which no efficient and safe weed control method is available and also against particular weeds such as broom rape which is a big menace in tobacco cultivation. Studies need to be initiated in this aspect. For crops of high value such as Tobacco and vegetables, use of solarization becomes more economically
feasible for management of soil borne diseases such as root-knot, damping off and black shank. In depth integrated investigation in that direction is essential for attaining pathogen proof nursery ecosystem which is latent in present investigation.

The investigation to avoid penetration of UV light transmitted with appropriate LDPE sheet are obligatory to prevent mortality of beneficial microorganisms, which may open new vistas in creating better economy in nursery production. Besides, further attempts to reduce the thickness of LDPE sheets is essential, which permits better penetration of sun light resulting in still more effective solarization, however documenting the field feasibility and problems.

**Recommendation**

Root-knot menace is multiplying year after year due to monoculturing of tobacco and other solanaceous crops like brinjal, tomato and other root-knot susceptible crops. There is dearth of nematicides besides their cost residual effects both in soil and environment, health hazardness etc. Other methods suggested for root-knot management such as crop rotation with non-host crops, flooding, fallow are not practicable.
Soil solarization is a simple, ecofriendly method which not only minimizes root-knot disease but also other soil borne diseases like damping off and block shank, weed population will be restricted. In addition to this, seedling production will be boosted with enhanced availability of nutrients.

Moreover, seedlings obtained from solarized beds will be more strong and healthy. Thus, by adopting solarization technique, farmers can manage three diseases besides weeds.

By adopting soil solarization the following benefits are achieved in tobacco nursery ecosystem.

1. Reduction in root-knot index.
2. Reduction in incidence of damping off disease.
4. Minimized weed intensity.
5. Increased number of healthy transplantable seedlings.
6. Enhanced availability of nutrients to seedlings.