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# Control of root-knot nematode by using composted sawdust in tomato root

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**The effect of composted sawdust at different concentrations (0, 10, 20... 100% v/v in soil) on tomato plant growth and pigments were investigated with or without the presence of root-knot nematode, *Meloidogyne javanica* at different inoculum levels (0, 1000, 2000, 3000, 4000, 5000) in clay pots (having diameter 30 cm and depth 60 cm). An increase in the composted sawdust concentration in the field soil progressively increased the availability of chlorides, sulphates, carbonates, bicarbonates, P, K, Mg, Mn, Cu, Zn and Fe. However, reverse trend was evaluated in nitrogen content of the soil with gradual increment in sawdust. Different physical properties such as porosity, pH, conductivity, water holding and cation exchange capacity also increased gradually with gradual sawdust amendment in the soil. Sawdust application enhanced the plant growth as well as leaf pigments in both nematode infected as well as non-infected tomato plants, being maximum in the soil containing 30% composted sawdust. Growth and leaf pigments also showed reductions with respect to increase in nematode inoculum density compared to nematode union-culated plants (that is, controls). However, least amount of tomato growth and leaf pigments were found at 3000 nematode inoculum level. Sawdust treatments favorably affect the root invasion by root-knot nematode juveniles (J2 and J3 + J4) and galls up to 30% but adversely affected onward treatments although, a gradual increase in sawdust concentration in the soil would correspondingly decrease the number of egg masses and eggs per egg mass (that is, fecundity) of the root-knot nematodes. All the above said nematode parameters were also improved with all considered nematode inoculum levels but 3000 was the optimum level for them. After visualizing the results, it can be suggested that 30% composted sawdust was the most economical level as it enhances the growth and pigments irrespective of the presence or absence of root-knot nematode. At the same time, it also controls the root-knot nematodes in particularly in 30% onward dust amendments.**

**Key words:** Meloidogyne javanica, nematode,sawdust.

## INTRODUCTION

Sawdust, composed of fine particles of wood are the by-product of sawmills. It litters into the surrounding area and accumulates as fine particles in the soil. It adds some harmful and toxic leachates to the soil and thus to the water

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system. The water born bacteria digest organic material present in leachates and use up much of the available oxygen and increase the biochemical oxygen demand of the water. However, some reports are also available regarding the improvement in nutritional pool of the soil through composted sawdust additions (Obasi et al., 2013). It also improves some of the physico-chemical properties of the soil such as soil porosity (Imre et al., 2011). Recently, Hassan et al. (2010) have reported the growth promoting effects of sawdust on tomato plants.

Root-knot nematode, *Meloidogyne* species happens to be an important pest parasite on different vegetable plants in tropical as well as subtropical countries. Root-knot nematode attacks several kind of crop all over the world due their wide host range. The nematode presence may cause the damage from 25 to 60% in yield (Akhtar et al., 2012). The nematode density is also a matter of concern to the crop growth and yield (Hong et al., 2011). Although, some reports are available regarding the inhibitory effect of sawdust on nematodes due to formation of phenolic compounds through the decomposition of sawdust (Kokalis-Burelle et al.,1994). However, it is not possible to draw systematically available information based on the interaction of nematodes with variable density in the presence of different sawdust concentrations. So far there are no available literatures with respect to meticulous utilization of sawdust to control the root-knot nematode in their parasitic or nonparasitic phases. So here an experiment was designed to assess the potentiality of sawdust as the nematicide and/or fertilizer, which can be utilized for the management of the root-knot nematode on one hand as well as crop growth improvement on the other.

## MATERIALS AND METHODS

Sawdust used in this experiment was collected from sawmill situated at Quarsi, the suburb of Aligarh (U.P.). Sawdust was composted for three months in a dug out pit for decomposition. The composted sawdust and field loamy soil (procured from field) were sun dried for a week and then mixed in requisite quantities to obtain the different sawdust levels (that is, 0, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100% v/v) and filled (3 kg/pot) in clay pots having 30 cm upper diameters. The pots were then sterilized in autoclave maintained at 120°C temperature for 12 to 19 min at 20 lb pressure.

### Physio-chemical analysis

The physio-chemical characters of soil samples, with or without sawdust, were determined prior to seedling transplantation. But before analyzing such properties, fine particles of each sample were collected by passing them in a fine sieve. Porosity and water holding capacity were determined through hydrometry, pH by pH meters and CEC by analytical method. Carbonates and bicarbonates were determined by using the proper method. Nitrogen and phosphorus contents were also estimated by utilizing the appropriate technique. Zinc, copper, iron and manganese were determined by Diethylene triamine penta acetic acid (DTPA) method, potassium by ammonium acetate method and magnesium by mixed acid digestion method.

### Plant and nematode culture

Two-week-old seedlings of tomato, already grown in autoclaved field soil, were transplanted to the pots having sawdust and soil mixture in different proportions. One week after planting the seedlings, the pots which were designated to receive *M. javanica* were inoculated with freshly hatched second stage juveniles ($J_2$) of the root-knot nematode. Pure culture of $J_2$ was obtained from a single egg mass culture, which was done earlier in order to obtain the sufficient inoculum by culturing and sub culturing on the egg plants. For inoculation, the nematode suspension of 1 ml water containing 1000 juvenile (counting was done in counting dish) was added in holes made in the soil around a seedling as per treatment. Each treatment was replicated five times and pots were arranged in Complete Randomized Block Design (CRBD) on greenhouse benches (30±2°C) of Botanical Garden of D.S. College, Aligarh. After 90 days of growth, tomato plants were harvested for the measurement of various parameters.

### Estimation of plant growth

A few hours before termination of the experiment, an excess amount of water was added to the pots in order to soften the soil so that tomato plants could be uprooted softly without doing excessive loss to the roots. Uprooted plants were brought to the laboratory in the polypacks and lengths, fresh and dry weight of shoot and root were determined through standard procedure. The dry weight was however, determined after drying the shoot and root in hot air oven at 80°C for a full day and night.

### Estimation of pigments

The interveinal tissue from fresh leaves (1 g per plant) of unharvested plants was ground in 80% actone and filter through two Whatman No. 1 filter papers. The filtrate was use to determine carotenoid (MacLachlan and Zalik, 1963) and chlorophyll contents (MacKinney, 1941).

### Number of galls, egg masses, juveniles ($J_2$ and $J_3$ + $J_4$) and fecundity

At termination of the experiment, roots of harvested plants were washed under tap water for examination of nematode penetration level. Root samples (1 g) from different nematode treated plants were stained with acid fuchsin and lactophenol and pressed between two glass slides and examined under the compound microscope for second, third and fourth stage ($J_2$ and $J_3$ + $J_4$) juveniles of root-knot nematode in the roots.

Root galling and reproduction of the nematodes were determined by determining the number of galls and egg masses in tomato roots of nematode treated plants. The harvested plants were washed under tap water and examined for the presence of galls. Numbers of galls were counted in plant roots through naked eyes. Roots were immersed in an aqueous solution of phloxin B (0.15 g/lit tap water) for 15 min to stain the egg masses and then egg masses were counted. For the estimation of fecundity 10 egg masses shaked vigorously in 5.25 NaOCl solutions. The eggs were separated from egg masses and collected over 5000 mesh sieve. From the sieve the eggs were transferred to a beaker and 0.35% acid fuchsin (in 25% lactic acid) was added to 20 to 25 ml of suspension with boiling for 1 min for staining the eggs. After cooling, the eggs were counted and tabulated as eggs per egg mass.

### Statistical analysis

One factorial analysis was employed for the evaluation of different

**Table 1.** Effect of sawdust on physio-chemical properties of soil.

| Sawdust concentration (%) | Characteristic | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Porosity | WHC | pH | Conductivity | CEC | Sulphate (%) | Carbonate (%) | Bicarbonate (%) | Chloride (%) | Nitrogen (%) | Phosphorus (%) | Potassium (%) | Magnesium (%) | Manganese (µg/g) | Copper (µg/g) | Zinc (µg/g) | Iron (µg/g) |
| 0 | 48.5 | 33.7 | 6.2 | 3.8 | 5.7 | 4.62 | 0.45 | 0.69 | 0.31 | 0.16 | 0.05 | 0.24 | 0.07 | 18.1 | 2.12 | 1.15 | 7.48 |
| 10 | 51.7ns | 42.1* | 6.8* | 3.9ns | 5.9ns | 4.98* | 0.67* | 1.27* | 0.86* | 0.15* | 0.09* | 0.26ns | 0.10* | 163.5* | 8.35* | 10.50* | 11.640* |
| 20 | 54.7* | 46.4* | 5.7* | 4.0ns | 6.0ns | 5.14* | 0.98* | 1.79* | 1.08* | 0.14* | 0.13* | 0.29* | 0.15* | 274.3* | 9.34* | 23.70* | 132.40* |
| 30 | 63.7* | 48.8* | 7.0* | 4.1* | 6.0ns | 5.56* | 1.16* | 2.14* | 1.47* | 0.12* | 0.24* | 0.33* | 0.27* | 368.4* | 16.70* | 28.50* | 156.70* |
| 40 | 65.2* | 56.4* | 7.3* | 4.2* | 6.1* | 5.76* | 1.19* | 2.19* | 1.51* | 0.10* | 0.28* | 0.39* | 0.29* | 371.1* | 17.30* | 32.20* | 165.30* |
| 50 | 66.7* | 66.9* | 7.4* | 4.6* | 6.1* | 5.89* | 1.20* | 2.38* | 1.56* | 0.06* | 0.29* | 0.45* | 0.32* | 382.4* | 17.90* | 33.80* | 169.70* |
| 60 | 67.3* | 78.6* | 7.6* | 4.8* | 6.2* | 6.37* | 1.21* | 2.41* | 1.58* | 0.04* | 0.31* | 0.49* | 0.34* | 384.6* | 18.10* | 34.70* | 172.10* |
| 70 | 68.4* | 81.2* | 7.7* | 4.8* | 6.2* | 6.81* | 1.21* | 2.43* | 1.62* | 0.00* | 0.32* | 0.56* | 0.38* | 389.1* | 18.20* | 35.10* | 177.40* |
| 80 | 71.3* | 83.4* | 7.7* | 4.9* | 6.3* | 6.88* | 1.32* | 2.51* | 1.66* | 0.00* | 0.38* | 0.69* | 0.42* | 392.2* | 18.60* | 36.80* | 179.20* |
| 90 | 73.4* | 86.4* | 7.8* | 5.1* | 6.3* | 6.90* | 1.34* | 2.56* | 1.67* | 0.00* | 0.41* | 0.80* | 0.46* | 421.2* | 18.90* | 37.40* | 185.20* |
| 100 | 82.1* | 87.9* | 7.8* | 5.1* | 6.5* | 6.92* | 1.37* | 2.68* | 1.75* | 0.00* | 0.47* | 0.98* | 0.51* | 441.3* | 19.50* | 38.50* | 186.70* |
| LSD at 5% | 3.42 | 3.64 | 0.383 | 0.236 | 0.322 | 0.316 | 0.060 | 0.116 | 0.078 | 0.007 | 0.017 | 0.031 | 0.019 | 19.24 | 0.877 | 1.69 | 8.75 |

* = data significant with 0 inoculation level and 0% dust concentration at P=0.05; ns = not significant; # = data significant within a column at P=0.05; @ = data significant in a row at P = 0.05.

physio-chemical property data of soil with or without sawdust. The least significant difference (LSD) was calculated at P=0.05 by subjecting the data to Anova Table.

The data of tomato growth, leaf pigments and different root-knot disease parameters were analyzed by two factor analysis. The data are of two factors in which sawdust was considered as factor one ($F_1$) while different nematode inoculation levels were considered as factor two ($F_2$). The LSD was thus calculated separately for these factors along with their interactive LSD at P=0.05.

## RESULTS

### Physico-chemical properties

Data shows (Table 1) that the pH, conductivity, cation exchange capacity (CEC), water holding capa-city (WHC) and porosity were increased gradually with gradual increase in the sawdust level. Sulphate, carbonate, bicarbonate and chloride contents of sawdust were 49, 204, 288 and 464% compared to the field soil; thereby all were increased linearly with increase in sawdust concentration of field soil. Nitrogen contents were 0.160% in the field soil but were undetectable in sawdust particularly onward to 60% levels. A gradual increase in different metals (magnesium, manganese, copper, zinc and iron) was also observed in ever increasing level of sawdust.

### Plant growth and photosynthetic pigments

Plant growth in terms of length, fresh and dry weight of shoot and root and leaf photosynthetic pigments in terms of chlorophyll a, chl b, total chl and carotenoid contents were enhanced upto 30% sawdust level as evident from the data presented in Tables 2 to 6. Above 30% level, sawdust was however, proved detrimental to plant growth and photosynthetic pigments. The least value of these parameters was found in pure dust grown tomato plants. All growth related parameters including pigments were suppressed gradually with increase in the nematode density level from none (that is, control) to top levels (that is, 5000 inoculum level). However the maximum suppression to them was occurred at 3000 nematode level but this suppression was slightly masked at 4000 and 5000 nematode inoculation levels compared to 3000 level, although it was still

**Table 2.** Effect of sawdust on length of shoot and root (cm) of tomato plants.

| Sawdust concentration (%) | Parameters | Inoculation levels | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1000 | 2000 | 3000 | 4000 | 5000 | Mean |
| 0 | Shoot | 38.24 | $36.32^{ns}$ | 32.80* | 26.14* | 27.08* | 27.02* | 31.27 |
| | Root | 18.58 | $17.36^{ns}$ | $16.78^{ns}$ | $14.72^{ns}$ | $15.80^{ns}$ | $15.00^{ns}$ | 16.37 |
| 10 | Shoot | $38.80^{ns}$ | $36.70^{ns}$ | 33.10* | 26.40* | 28.20* | 27.40* | $31.77^{ns}$ |
| | Root | $18.50^{ns}$ | $17.70^{ns}$ | $17.20^{ns}$ | $15.20^{ns}$ | $16.20^{ns}$ | $15.60^{ns}$ | $16.73^{ns}$ |
| 20 | Shoot | $39.20^{ns}$ | $37.10^{ns}$ | $33.40^{*}$ | $26.70^{*}$ | $28.60^{*}$ | $27.80^{*}$ | $32.13^{\#}$ |
| | Root | $19.40^{ns}$ | $18.20^{ns}$ | $17.70^{ns}$ | $15.60^{ns}$ | $16.60^{ns}$ | $16.20^{ns}$ | $17.28^{\#}$ |
| 30 | Shoot | $39.60^{ns}$ | $37.60^{ns}$ | 33.90* | 27.00* | 29.00* | 28.40* | $32.58^{\#}$ |
| | Root | $20.00^{ns}$ | $18.60^{ns}$ | $18.30^{ns}$ | $16.20^{ns}$ | $17.00^{ns}$ | $16.80^{ns}$ | $17.82^{\#}$ |
| 40 | Shoot | $36.10^{ns}$ | 34.60* | 30.30* | 23.50* | 24.30* | 23.70* | $28.75^{\#}$ |
| | Root | $16.50^{ns}$ | $15.30^{ns}$ | $14.82^{ns}$ | $12.70^{ns}$ | $13.60^{ns}$ | $12.90^{ns}$ | $14.30^{\#}$ |
| 50 | Shoot | 29.80* | 26.80* | 22.50* | 19.00* | 22.70* | 21.20* | $23.67^{\#}$ |
| | Root | $15.30^{ns}$ | $14.10^{ns}$ | $12.90^{ns}$ | $10.80^{ns}$ | $11.86^{ns}$ | $11.20^{ns}$ | $12.69^{\#}$ |
| 60 | Shoot | 18.70* | 17.60* | 16.10* | 14.00* | 15.30* | 15.00* | $16.12^{\#}$ |
| | Root | $12.70^{ns}$ | $11.50^{ns}$ | $10.00^{ns}$ | $8.60^{ns}$ | $9.50^{ns}$ | $9.00^{ns}$ | $10.22^{\#}$ |
| 70 | Shoot | 13.90* | 11.50* | 10.80* | 9.20* | 10.50* | 9.80* | $10.95^{\#}$ |
| | Root | $10.40^{ns}$ | $10.00^{ns}$ | $9.10^{ns}$ | $8.50^{ns}$ | $9.00^{ns}$ | $8.80^{ns}$ | $9.30^{\#}$ |
| 80 | Shoot | 10.60* | 8.90* | 8.40* | 7.50* | 8.00* | 7.50* | $8.48^{\#}$ |
| | Root | $8.70^{ns}$ | $7.20^{ns}$ | $6.80^{ns}$ | $5.90^{ns}$ | $6.30^{ns}$ | $6.20^{ns}$ | $6.85^{\#}$ |
| 90 | Shoot | 8.80* | 8.00* | 7.70* | 6.80* | 7.50* | 7.10* | $7.65^{\#}$ |
| | Root | $6.50^{ns}$ | $6.00^{ns}$ | $5.60^{ns}$ | $5.00^{ns}$ | $5.50^{ns}$ | $5.20^{ns}$ | $5.63^{\#}$ |
| 100 | Shoot | 7.70* | 7.20* | 6.80* | 6.40* | 6.60* | 6.60* | $6.88^{\#}$ |
| | Root | $5.00^{ns}$ | $4.10^{ns}$ | $3.90^{ns}$ | $3.10^{ns}$ | $3.60^{ns}$ | $3.50^{ns}$ | $3.87^{\#}$ |
| Mean | Shoot | 25.59 | $23.85^{@}$ | $21.44^{@}$ | $17.51^{@}$ | $18.89^{@}$ | $18.32^{@}$ | |
| | Root | 13.78 | $12.73^{@}$ | $12.10^{@}$ | $10.57^{@}$ | $11.36^{@}$ | $10.95^{@}$ | |
| LSD at 5% | Shoot | Dust | 0.700 | Nematode inoculation | 0.947 | Interaction | 2.321 | |
| | Root | Dust | 0482 | Nematode inoculation | 0.653 | Interaction | NS | |

* = data significant with 0 inoculation level and 0% dust concentration at *P*=0.05; ns = Not significant; # = data significant within a column at *P* = 0.05; @ = data significant in a row at *P* = 0.05.

greater than controls.

Root-knot nematode caused significant suppressions to plant growth and leaf pigments in sawdust treated and untreated plants. However, the suppressive effects of the nematode gradually decreased with gradual increase in the sawdust concentration of the soil.

## Root-knot disease

The juvenile ($J_2$ and $J_3$+$J_4$) invasion was significantly impaired by different sawdust concentrations. This is evident from Table 7 and 10; there were increase upto 30% levels but decreased onward with dust additions. Likewise changes were recorded in root galling with respect to sawdust. As it was significantly improved upto 30% sawdust amendment (Table 8). There number suppressed in 30% onward sawdust treatments with the minimum number in 60% amendments. Egg masses and fecundity of the nematodes were suppressed gradually with gradual increase in sawdust concentration. All

**Table 3.** Effect of sawdust on fresh weight of shoot and root (g) of tomato plants.

| Sawdust concentration | Parameters | Inoculation levels | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1000 | 2000 | 3000 | 4000 | 5000 | Mean |
| 0 | Shoot | 35.20 | 33.08$^{ns}$ | 31.50$^{ns}$ | 27.44$^{ns}$ | 29.22$^{ns}$ | 28.64$^{ns}$ | 30.85 |
| | Root | 13.50 | 12.90$^{ns}$ | 11.80$^{*}$ | 10.10$^{*}$ | 11.70$^{*}$ | 11.20$^{*}$ | 11.87 |
| 10 | Shoot | 36.70$^{ns}$ | 34.20$^{ns}$ | 32.10$^{ns}$ | 28.40$^{ns}$ | 30.70$^{ns}$ | 29.30$^{ns}$ | 31.90$^{\#}$ |
| | Root | 13.90$^{ns}$ | 13.40$^{ns}$ | 11.90$^{*}$ | 10.40$^{*}$ | 12.00$^{*}$ | 11.80$^{*}$ | 12.17$^{\#}$ |
| 20 | Shoot | 37.90$^{ns}$ | 35.40$^{ns}$ | 33.40$^{ns}$ | 29.70$^{ns}$ | 31.50$^{ns}$ | 30.20$^{ns}$ | 33.02$^{\#}$ |
| | Root | 14.50$^{*}$ | 13.80$^{ns}$ | 12.90$^{*}$ | 10.72$^{*}$ | 12.40$^{*}$ | 12.20$^{*}$ | 12.59$^{\#}$ |
| 30 | Shoot | 38.50$^{ns}$ | 36.70$^{ns}$ | 33.90$^{ns}$ | 30.10$^{ns}$ | 32.70$^{ns}$ | 31.00$^{ns}$ | 33.82$^{\#}$ |
| | Root | 14.90$^{*}$ | 14.26$^{ns}$ | 13.40$^{ns}$ | 11.50 | 12.80$^{ns}$ | 12.50$^{*}$ | 13.23$^{\#}$ |
| 40 | Shoot | 35.48$^{ns}$ | 33.20$^{ns}$ | 30.10$^{ns}$ | 27.50$^{ns}$ | 29.40$^{ns}$ | 28.80$^{ns}$ | 30.75$^{\#}$ |
| | Root | 14.20$^{ns}$ | 13.30$^{ns}$ | 12.80$^{ns}$ | 11.30$^{*}$ | 12.40$^{*}$ | 11.90$^{*}$ | 12.65$^{\#}$ |
| 50 | Shoot | 30.20$^{ns}$ | 28.70$^{ns}$ | 26.70$^{ns}$ | 24.80$^{ns}$ | 26.70$^{ns}$ | 25.70$^{ns}$ | 27.13$^{\#}$ |
| | Root | 12.66$^{ns}$ | 11.20$^{*}$ | 10.80$^{*}$ | 9.90$^{*}$ | 10.40$^{*}$ | 10.20$^{*}$ | 10.86$^{\#}$ |
| 60 | Shoot | 27.66$^{ns}$ | 25.30$^{ns}$ | 23.20$^{ns}$ | 21.60$^{ns}$ | 22.90$^{ns}$ | 22.40$^{ns}$ | 23.84$^{\#}$ |
| | Root | 11.10$^{*}$ | 9.10$^{*}$ | 8.10$^{*}$ | 6.72$^{*}$ | 7.70$^{*}$ | 7.10$^{*}$ | 8.39$^{\#}$ |
| 70 | Shoot | 20.50$^{ns}$ | 18.80$^{ns}$ | 16.50$^{ns}$ | 14.30$^{ns}$ | 15.70$^{ns}$ | 15.00$^{ns}$ | 16.80$^{\#}$ |
| | Root | 8.60$^{*}$ | 7.00$^{*}$ | 6.80$^{*}$ | 6.10$^{*}$ | 6.60$^{*}$ | 6.40$^{*}$ | 6.92$^{\#}$ |
| 80 | Shoot | 18.90$^{ns}$ | 16.50$^{ns}$ | 14.10$^{ns}$ | 11.20$^{ns}$ | 13.50$^{ns}$ | 12.20$^{ns}$ | 14.40$^{\#}$ |
| | Root | 6.10$^{*}$ | 5.80$^{*}$ | 5.50$^{*}$ | 5.00$^{*}$ | 5.20$^{*}$ | 4.80$^{*}$ | 5.40$^{\#}$ |
| 90 | Shoot | 14.70$^{ns}$ | 12.00$^{ns}$ | 10.30$^{ns}$ | 7.30$^{ns}$ | 9.00$^{ns}$ | 8.70$^{ns}$ | 10.33$^{\#}$ |
| | Root | 5.80$^{*}$ | 5.20$^{*}$ | 4.70$^{*}$ | 4.20$^{*}$ | 4.50$^{*}$ | 4.50$^{*}$ | 4.82$^{\#}$ |
| 100 | Shoot | 8.80$^{ns}$ | 6.90$^{ns}$ | 6.50$^{ns}$ | 5.50$^{ns}$ | 6.00$^{ns}$ | 5.80$^{ns}$ | 6.58$^{\#}$ |
| | Root | 4.50$^{*}$ | 4.00$^{*}$ | 3.60$^{*}$ | 3.20$^{*}$ | 3.40$^{*}$ | 3.40$^{*}$ | 3.68$^{\#}$ |
| Mean | Shoot | 27.69 | 25.53$^{@}$ | 23.48$^{@}$ | 20.71$^{@}$ | 22.48$^{@}$ | 21.61$^{@}$ | |
| | Root | 10.89 | 10.04$^{@}$ | 9.17$^{@}$ | 8.10$^{@}$ | 9.01$^{@}$ | 8.73$^{@}$ | |
| LSD at 5% | Shoot | Dust | 0.916 | Nematode inoculation | 1.241 | Interaction | NS | |
| | Root | Dust | 0.260 | Nematode inoculation | 0.353 | Interaction | 0.864 | |

* = data significant with 0 inoculation level and 0% dust concentration at *P*=0.05; ns = Not significant; # = data significant within a column at *P* = 0.05; @ = data significant in a row at *P* = 0.05.

these nematode parameters were found nil in 70, 80, 90 and 100% sawdust additions (Tables 9 and 10).

## DISCUSSION

Sawdust has gradually improved the growth and photosynthetic pigments of the tomato plants up to 30% amendments. Some reports are also available with regards to positive effects of sawdust on plant growth (Hassan et al., 2010). Improvement in different physio-chemical properties of the soil with sawdust additions (Table 1) are in concurrence with the earlier work (Obasi et al., 2013). The optimization in the soil properties has occurred most appropriately at 30% dust addition as evident from the maximization of tomato's growth and pigments in such treatments. Reverse effects of sawdust were observed on the growth and pigments of tomato plants beyond 30% amendments. At higher levels, accumulation of heavy metals beyond threshold

**Table 4.** Effect of sawdust on dry weight of shoot and root (g) of tomato plants.

| Sawdust concentration | Parameters | Inoculation levels | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1000 | 2000 | 3000 | 4000 | 5000 | Mean |
| 0 | Shoot | 7.70 | 7.41$^{ns}$ | 6.60$^{ns}$ | 5.94$^{ns}$ | 6.45$^{ns}$ | 6.27$^{ns}$ | 6.73 |
| | Root | 2.90 | 2.80$^{ns}$ | 2.70$^{ns}$ | 2.30$^{ns}$ | 2.52$^{ns}$ | 2.43$^{ns}$ | 2.61 |
| 10 | Shoot | 8.00$^{ns}$ | 7.80$^{ns}$ | 7.30$^{ns}$ | 6.80$^{ns}$ | 7.20$^{ns}$ | 7.00$^{ns}$ | 7.35$^{\#}$ |
| | Root | 3.10$^{ns}$ | 3.00$^{ns}$ | 2.90$^{ns}$ | 2.50$^{ns}$ | 2.80$^{ns}$ | 2.60$^{ns}$ | 2.82$^{\#}$ |
| 20 | Shoot | 8.70$^{ns}$ | 8.20$^{ns}$ | 7.90$^{ns}$ | 7.30$^{ns}$ | 7.80$^{ns}$ | 7.70$^{ns}$ | 7.93$^{\#}$ |
| | Root | 3.30$^{ns}$ | 3.20$^{ns}$ | 3.10$^{ns}$ | 2.94$^{ns}$ | 3.00$^{ns}$ | 3.00$^{ns}$ | 3.09$^{\#}$ |
| 30 | Shoot | 9.30$^{ns}$ | 8.90$^{ns}$ | 8.50$^{ns}$ | 8.10$^{ns}$ | 8.40$^{ns}$ | 8.20$^{ns}$ | 8.57$^{\#}$ |
| | Root | 3.50$^{ns}$ | 3.40$^{ns}$ | 3.20$^{ns}$ | 3.10$^{ns}$ | 3.20$^{ns}$ | 3.10$^{ns}$ | 3.25$^{\#}$ |
| 40 | Shoot | 7.90$^{ns}$ | 7.20$^{ns}$ | 6.90$^{ns}$ | 6.10$^{ns}$ | 6.80$^{ns}$ | 6.60$^{ns}$ | 6.92$^{ns}$ |
| | Root | 3.10$^{ns}$ | 3.00$^{ns}$ | 2.70$^{ns}$ | 2.30$^{ns}$ | 2.60$^{ns}$ | 2.40$^{ns}$ | 2.68$^{ns}$ |
| 50 | Shoot | 7.20$^{ns}$ | 6.90$^{ns}$ | 6.40$^{ns}$ | 5.70$^{ns}$ | 6.20$^{ns}$ | 6.10$^{ns}$ | 6.42$^{\#}$ |
| | Root | 3.00$^{ns}$ | 2.60$^{ns}$ | 2.50$^{ns}$ | 2.20$^{ns}$ | 2.40$^{ns}$ | 2.30$^{ns}$ | 2.50$^{ns}$ |
| 60 | Shoot | 6.80$^{ns}$ | 6.40$^{ns}$ | 6.00$^{ns}$ | 5.40$^{ns}$ | 5.80$^{ns}$ | 5.60$^{ns}$ | 6.00$^{\#}$ |
| | Root | 2.80$^{ns}$ | 2.20$^{ns}$ | 2.00$^{ns}$ | 1.50$^{ns}$ | 1.80$^{ns}$ | 1.60$^{ns}$ | 1.98$^{\#}$ |
| 70 | Shoot | 6.30$^{ns}$ | 6.00$^{ns}$ | 5.50$^{ns}$ | 5.10$^{ns}$ | 5.40$^{ns}$ | 5.20$^{ns}$ | 5.58$^{\#}$ |
| | Root | 2.40$^{ns}$ | 2.00$^{ns}$ | 1.70$^{ns}$ | 1.30$^{ns}$ | 1.50$^{ns}$ | 1.50$^{ns}$ | 1.73$^{\#}$ |
| 80 | Shoot | 5.00$^{ns}$ | 4.80$^{ns}$ | 4.60$^{ns}$ | 4.20$^{ns}$ | 4.40$^{ns}$ | 4.40$^{ns}$ | 4.57$^{\#}$ |
| | Root | 2.00$^{ns}$ | 1.80$^{ns}$ | 1.60$^{ns}$ | 1.10$^{ns}$ | 1.40$^{ns}$ | 1.20$^{ns}$ | 1.52$^{\#}$ |
| 90 | Shoot | 3.70$^{ns}$ | 3.40$^{ns}$ | 3.20$^{ns}$ | 2.50$^{ns}$ | 3.00$^{ns}$ | 2.80$^{ns}$ | 3.10$^{\#}$ |
| | Root | 1.50$^{ns}$ | 1.30$^{ns}$ | 1.10$^{ns}$ | 0.90$^{ns}$ | 1.00$^{ns}$ | 1.00$^{ns}$ | 1.13$^{\#}$ |
| 100 | Shoot | 2.20$^{ns}$ | 2.10$^{ns}$ | 2.04$^{ns}$ | 1.70$^{ns}$ | 1.90$^{ns}$ | 1.90$^{ns}$ | 1.97$^{\#}$ |
| | Root | 1.20$^{ns}$ | 1.00$^{ns}$ | 1.00$^{ns}$ | 0.80$^{ns}$ | 1.00$^{ns}$ | 1.00$^{ns}$ | 1.00$^{\#}$ |
| Mean | Shoot | 6.62 | 6.28$^{@}$ | 5.90$^{@}$ | 5.35$^{@}$ | 5.76$^{@}$ | 5.62$^{@}$ | |
| | Root | 2.62 | 2.39$^{@}$ | 2.23$^{@}$ | 1.90$^{@}$ | 2.11$^{@}$ | 2.01$^{@}$ | |
| LSD at 5% | Shoot | Dust | 0.189 | Nematode inoculation | 0.256 | Interaction | NS | |
| | Root | Dust | 0.138 | Nematode inoculation | 0.187 | Interaction | NS | |

* = data significant with 0 inoculation level and 0% dust concentration at *P*=0.05; ns = Not significant; # = data significant within a column at *P* = 0.05; @ = data significant in a row at *P* = 0.05.

limit for plants can be advocated as reason behind such adversaries on growth fronts. Since nitrogen being an integral part of the chlorophyll (Javedi, 2014) so nitrogen immobilization due to its more deficiency at higher dust amendments could also be interpreted as healthy reason behind such poor growth and pigmentation of tomato. Higher doses of sawdust are reported to be phytotoxic to tomato growth and yield (Siddiqui and Alam, 1990).

The reduction in growth and leaf pigments of tomato plants of about 3000 root-knot nematode inoculum levels could be due to the formation of galls through hyperplastic and hypertropic phenol-menon. The sedentary females of *M. javanica* obtained food from such galls. The nutrients

**Table 5.** Effect of sawdust on chlorophyll ‘a’ and chlorophyll ‘b’ (µg/g) of tomato leaves.

| Sawdust concentration | Parameters | Inoculation levels | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1000 | 2000 | 3000 | 4000 | 5000 | Mean |
| 0 | Chl.a | 520.0 | 507.0$^{ns}$ | 498.0$^{ns}$ | 480.0$^{ns}$ | 493.0$^{ns}$ | 490.0$^{ns}$ | 498.00 |
| | Chl.b | 235.00 | 227.00* | 219.00* | 203.00* | 215.00* | 212.00* | 218.50 |
| 10 | Chl.a | 535.0$^{ns}$ | 525.0$^{ns}$ | 517.0$^{ns}$ | 502.0$^{ns}$ | 512.0$^{ns}$ | 508.0$^{ns}$ | 516.5$^{\#}$ |
| | Chl.b | 238.00* | 231.00* | 226.00* | 212.00* | 222.00* | 218.00* | 224.50$^{\#}$ |
| 20 | Chl.a | 547.0$^{ns}$ | 535.0$^{ns}$ | 527.0$^{ns}$ | 515.0$^{ns}$ | 524.0$^{ns}$ | 520.0$^{ns}$ | 528.0$^{\#}$ |
| | Chl.b | 241.00$^{*}$ | 237.00$^{ns}$ | 233.00$^{ns}$ | 220.00$^{*}$ | 229.00$^{*}$ | 225.00$^{*}$ | 230.83$^{\#}$ |
| 30 | Chl.a | 560.0$^{ns}$ | 549.0$^{ns}$ | 538.0$^{ns}$ | 529.0$^{ns}$ | 535.0$^{ns}$ | 530.0$^{ns}$ | 540.2$^{\#}$ |
| | Chl.b | 245.00* | 241.00* | 238.00* | 231.00* | 235.00$^{ns}$ | 233.00$^{ns}$ | 237.17$^{\#}$ |
| 40 | Chl.a | 512.0$^{ns}$ | 500.0$^{ns}$ | 472.0$^{ns}$ | 450.0$^{ns}$ | 465.0$^{ns}$ | 457.0$^{ns}$ | 476.0$^{\#}$ |
| | Chl.b | 236.00$^{ns}$ | 230.00* | 223.00* | 215.00* | 221.00* | 218.80* | 223.97$^{\#}$ |
| 50 | Chl.a | 480.0$^{ns}$ | 468.0$^{ns}$ | 457.0$^{ns}$ | 447.0$^{ns}$ | 454.0$^{ns}$ | 451.0$^{ns}$ | 459.5$^{\#}$ |
| | Chl.b | 225.00* | 219.00* | 211.00* | 201.00* | 208.00* | 205.00* | 211.50$^{\#}$ |
| 60 | Chl.a | 450.0$^{ns}$ | 436.0$^{ns}$ | 425.0$^{ns}$ | 417.0$^{ns}$ | 420.0$^{ns}$ | 418.2$^{ns}$ | 427.7$^{\#}$ |
| | Chl.b | 213.00* | 205.00* | 193.00* | 182.00* | 190.20* | 185.00* | 194.70$^{\#}$ |
| 70 | Chl.a | 410.0$^{ns}$ | 395.0$^{ns}$ | 377.0$^{ns}$ | 353.0$^{ns}$ | 370.0$^{ns}$ | 365.0$^{ns}$ | 378.3$^{\#}$ |
| | Chl.b | 202.00* | 195.00* | 182.00* | 170.00* | 180.00* | 176.00* | 184.17$^{\#}$ |
| 80 | Chl.a | 350.0$^{ns}$ | 325.0$^{ns}$ | 307.0$^{ns}$ | 282.0$^{ns}$ | 302.0$^{ns}$ | 290.0$^{ns}$ | 309.3$^{\#}$ |
| | Chl.b | 184.00* | 172.00* | 163.00* | 152.00* | 161.00* | 156.00* | 164.67$^{\#}$ |
| 90 | Chl.a | 300.0$^{ns}$ | 272.0$^{ns}$ | 252.0$^{ns}$ | 227.0$^{ns}$ | 246.0$^{ns}$ | 234.8$^{ns}$ | 255.3$^{\#}$ |
| | Chl.b | 146.00* | 138.00* | 127.00* | 118.00* | 124.00* | 120.00* | 128.83$^{\#}$ |
| 100 | Chl.a | 110.0$^{ns}$ | 98.0$^{ns}$ | 86.0$^{ns}$ | 60.0$^{ns}$ | 79.0$^{ns}$ | 72.0$^{ns}$ | 84.2$^{\#}$ |
| | Chl.b | 112.00* | 105.20* | 97.00* | 86.00* | 93.00* | 89.00* | 97.03$^{\#}$ |
| Mean | Chl.a | 434.00 | 419.1$^{@}$ | 405.1$^{@}$ | 387.5$^{@}$ | 400.0$^{@}$ | 394.2$^{@}$ | |
| | Chl.b | 207.00 | 200.02$^{@}$ | 192.00$^{@}$ | 180.91$^{@}$ | 188.93$^{@}$ | 185.25$^{@}$ | |
| LSD at 5% | Chl.a | Dust | 9.698 | Nematode inoculation | 13.132 | Interaction | NS | |
| | Chl.b | Dust | 0.875 | Nematode inoculation | 1.185 | Interaction | 2.903 | |

* = data significant with 0 inoculation level & 0% dust concentration at $P$=0.05; ns = Not significant; # = data significant within a column at $P$ = 0.05; @ = data significant in a row at $P$ = 0.05.

continuously sucked by the nematode females, would subsequently be not available to plant to perform better at growth and leaf pigmentation front. Root-knot nematodes are also known to bring about an extensive alteration in the vascular tissues of the host plants therefore supply of water and nutrients are disturbed (Singh and Khan, 1999). The reduction occurred in plant growth and photosynthetic pigments was slightly masked at 4000 and 5000 compared to 3000 nematode inoculum levels although insignificant. Antagonistic interaction and/or intraspecific competition amongst the nematode (for food and space) could be extended as the reason beyond such insignificant improvements.

**Table 6.** Effect of sawdust on total chlorophyll and carotenoid (μg/g) of tomato leaves.

| Sawdust concentration (%) | Parameters | Inoculation levels | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1000 | 2000 | 3000 | 4000 | 5000 | Mean |
| 0 | Chl | 760.00 | 737.00* | 720.00* | 685.00* | 712.00* | 708.00* | 720.33 |
| | Carot. | 4.24 | 3.90$^{ns}$ | 3.70$^{ns}$ | 3.40$^{ns}$ | 3.60$^{ns}$ | 3.60$^{ns}$ | 3.74 |
| 10 | Chl | 782.00* | 762.00$^{ns}$ | 752.00* | 721.00* | 742.00* | 733.00* | 748.67$^{\#}$ |
| | Carot. | 4.30$^{ns}$ | 4.10$^{ns}$ | 3.90$^{ns}$ | 3.50$^{ns}$ | 3.80$^{ns}$ | 3.70$^{ns}$ | 3.88$^{\#}$ |
| 20 | Chl | 795.00* | 783.00* | 765.00* | 743.00* | 759.00$^{ns}$ | 751.00* | 766.00$^{\#}$ |
| | Carot. | 4.50$^{ns}$ | 4.30$^{ns}$ | 4.10$^{ns}$ | 3.80$^{ns}$ | 4.00$^{ns}$ | 3.90$^{ns}$ | 4.10$^{\#}$ |
| 30 | Chl | 813.00* | 794.00* | 782.00* | 765.00* | 778.00* | 769.00* | 783.50$^{\#}$ |
| | Carot. | 4.90$^{ns}$ | 4.70$^{ns}$ | 4.40$^{ns}$ | 4.20$^{ns}$ | 4.30$^{ns}$ | 4.30$^{ns}$ | 4.47$^{\#}$ |
| 40 | Chl | 755.00* | 737.00* | 702.00* | 673.00* | 693.00* | 683.00* | 707.17$^{\#}$ |
| | Carot. | 4.80$^{ns}$ | 4.60$^{ns}$ | 4.30$^{ns}$ | 4.00$^{ns}$ | 4.20$^{ns}$ | 4.10$^{ns}$ | 4.33$^{\#}$ |
| 50 | Chl | 713.00* | 691.00* | 676.00* | 653.00* | 668.00* | 663.00* | 677.33$^{\#}$ |
| | Carot. | 4.40$^{ns}$ | 4.20$^{ns}$ | 4.02$^{ns}$ | 3.70$^{ns}$ | 3.90$^{ns}$ | 3.90$^{ns}$ | 4.02$^{\#}$ |
| 60 | Chl | 672.00* | 700.00* | 626.00* | 607.00* | 619.00* | 609.00* | 638.83$^{\#}$ |
| | Carot. | 4.10$^{ns}$ | 3.80$^{ns}$ | 3.66$^{ns}$ | 3.30$^{ns}$ | 3.50$^{ns}$ | 3.40$^{ns}$ | 3.63$^{\#}$ |
| 70 | Chl | 620.00* | 597.00* | 565.20* | 532.00* | 557.00* | 549.00* | 570.03* |
| | Carot. | 3.90$^{ns}$ | 3.70$^{ns}$ | 3.40$^{ns}$ | 3.00$^{ns}$ | 3.20$^{ns}$ | 3.10$^{ns}$ | 3.38$^{\#}$ |
| 80 | Chl | 540.00* | 507.00* | 477.00* | 441.00* | 467.00* | 453.00* | 480.83$^{\#}$ |
| | Carot. | 3.50$^{ns}$ | 3.30$^{ns}$ | 3.20$^{ns}$ | 2.80$^{ns}$ | 3.00$^{ns}$ | 3.00$^{ns}$ | 3.13$^{\#}$ |
| 90 | Chl | 452.00* | 418.00* | 387.00* | 352.40* | 378.00* | 364.00* | 391.90$^{\#}$ |
| | Carot. | 3.00$^{ns}$ | 2.90$^{ns}$ | 2.60$^{ns}$ | 2.20$^{ns}$ | 2.40$^{ns}$ | 2.30$^{ns}$ | 2.57$^{\#}$ |
| 100 | Chl | 231.00* | 209.00* | 190.00* | 152.00* | 179.00* | 167.00* | 188.00$^{\#}$ |
| | Carot. | 2.50$^{ns}$ | 2.30$^{ns}$ | 2.10$^{ns}$ | 1.90$^{ns}$ | 2.10$^{ns}$ | 2.00$^{ns}$ | 2.15$^{\#}$ |
| Mean | Chl | 648.45 | 630.45$^{@}$ | 603.84$^{@}$ | 574.95$^{@}$ | 595.64$^{@}$ | 586.27$^{@}$ | |
| | Carot. | 4.01 | 3.80$^{@}$ | 3.58$^{@}$ | 3.25$^{@}$ | 3.45$^{@}$ | 3.39$^{@}$ | |
| LSD at 5% | Chl | Dust | 1.251 | Nematode inoculation | 1.694 | Interaction | 4.148 | |
| | Chl.b | Dust | 0.111 | Nematode inoculation | 0.151 | Interaction | NS | |

* = data significant with 0 inoculation level and 0% dust concentration at *P*=0.05, ns = Not significant, # = data significant within a column at *P* = 0.05, @ = data significant in a row at *P* = 0.05.

As per results of growth and leaf pigments for the nematode infected tomato plants, they increased upto 30% sawdust additions in the field soil. Promoted plant growth upto 30% dust could probably generate surplus nutrients. On the other hand sawdust amendments up to 30% facilitate the free movement of juvenile (O'Bannon and Raynolds, 1961) through improving the porosity of the field soil which might be responsible for greater root penetration. Greater number of engrossed second stage juvenile ($J_2$) would subsequently be metamorphosed into greater number of third and fourth stage juveniles ($J_3$+$J_4$). They would have to be transformed into females and subsequently through sedentary parasitism.

**Table 7.** Effect of sawdust on number of $J_2$ and $J_3$+$J_4$ of root-knot nematode on tomato plants.

| Sawdust concentration (%) | Parameters | Inoculation levels | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1000 | 2000 | 3000 | 4000 | 5000 | Mean |
| 0 | $J_2$ | 0.0 | 1702.0* | 1796.0* | 1997.0* | 1845.0* | 1825.0* | 1527.50 |
| | $J_3$+$J_4$ | 0.0 | 390.0* | 439.0* | 500.0* | 478.0* | 467.0* | 379.0 |
| 10 | $J_2$ | 0.0$^{ns}$ | 1772.0* | 1836.0* | 2005.0* | 1865.0* | 1835.0* | 1552.1$^{ns}$ |
| | $J_3$+$J_4$ | 0.0$^{ns}$ | 415.0* | 467.0* | 543.0* | 538.0* | 527.0* | 415.0$^{\#}$ |
| 20 | $J_2$ | 0.0$^{ns}$ | 1820.0* | 1883.0* | 2015.0* | 1904.0* | 1887.0* | 1584.8$^{\#}$ |
| | $J_3$+$J_4$ | 0.0$^{ns}$ | 445.0* | 498.0* | 570.0* | 553.0* | 543.0* | 434.8$^{\#}$ |
| 30 | $J_2$ | 0.0$^{ns}$ | 1865.0* | 1940.0* | 2035.0* | 2015.0* | 1973.0* | 1638.0$^{\#}$ |
| | $J_3$+$J_4$ | 0.0$^{ns}$ | 470.0* | 537.0* | 610.0* | 594.0* | 587.0* | 466.3$^{\#}$ |
| 40 | $J_2$ | 0.0$^{ns}$ | 1753.0* | 1822.0* | 1905.0* | 1850.0* | 1839.0* | 1528.2$^{ns}$ |
| | $J_3$+$J_4$ | 0.0$^{ns}$ | 412.0* | 440.0* | 478.0* | 468.0* | 455.0* | 375.5$^{\#}$ |
| 50 | $J_2$ | 0.0$^{ns}$ | 973.0* | 1033.0* | 1130.8* | 1070.0* | 1028.0* | 872.5$^{\#}$ |
| | $J_3$+$J_4$ | 0.0$^{ns}$ | 305.0* | 338.0* | 369.0* | 358.0* | 345.0* | 285.8$^{\#}$ |
| 60 | $J_2$ | 0.0$^{ns}$ | 437.0* | 527.0* | 638.0* | 569.0* | 556.0* | 454.5$^{\#}$ |
| | $J_3$+$J_4$ | 0.0$^{ns}$ | 210.0* | 227.0* | 265.0* | 252.0* | 240.0* | 199.0$^{\#}$ |
| 70 | $J_2$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| | $J_3$+$J_4$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| 80 | $J_2$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| | $J_3$+$J_4$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| 90 | $J_2$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| | $J_3$+$J_4$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| 100 | $J_2$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| | $J_3$+$J_4$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| Mean | $J_2$ | 0.00 | 938.4$^{@}$ | 985.2$^{@}$ | 1056.2$^{@}$ | 1008.9$^{@}$ | 996.6$^{@}$ | |
| | $J_3$+$J_4$ | 0.00 | 240.6$^{@}$ | 267.8$^{@}$ | 303.2$^{@}$ | 294.6$^{@}$ | 287.6$^{@}$ | |
| LSD at 5% | $J_2$ | Dust | 31.441 | Nematode inoculation | 42.571 | Interaction | 104.278 | |
| | $J_3$+$J_4$ | Dust | 16.051 | Nematode inoculation | 21.734 | Interaction | 53.236 | |

* = data significant with 0 inoculation level and 0% dust concentration at $P$=0.05; ns = Not significant; # = data significant within a column at $P$ = 0.05; @ = data significant in a row at $P$ = 0.05.

The above said reason may be stemmed as a link towards increase in the number of all type of juveniles and galls upto 30% sawdust levels. But egg masses and fecundity showed gradual suppressions with respect to progressive increase in sawdust. They (including juveniles and soils) were absolutely absent up till 70% dust addition treatments.

The inhibitory effect of sawdust on nematodes can be attributed to the formation of phenolic compounds by the decomposition of sawdust (Kokalis-Burelle et al., 1994). For juveniles and galling, the concentration of some formed phenollic compounds of about 30% dust amendments could not have crossed the threshold limit so as

**Table 8.** Effect of sawdust on number of galls of root-knot nematode on tomato plants.

| Sawdust concentration (%) | Inoculation levels | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 1000 | 2000 | 3000 | 4000 | 5000 | Mean |
| 0 | 0.0 | 75.00* | 87.00* | 104.00* | 96.00* | 91.00* | 75.50 |
| 10 | 0.0$^{ns}$ | 79.00* | 95.00* | 112.00* | 107.00* | 102.00* | 82.50$^{\#}$ |
| 20 | 0.0$^{ns}$ | 85.00* | 106.00* | 118.00* | 115.00* | 110.00* | 89.00$^{\#}$ |
| 30 | 0.0$^{ns}$ | 93.00* | 110.00* | 127.00* | 120.00* | 119.00* | 94.83$^{\#}$ |
| 40 | 0.0$^{ns}$ | 72.00* | 85.00* | 96.00* | 92.00* | 88.00* | 72.17$^{\#}$ |
| 50 | 0.0$^{ns}$ | 48.00* | 57.00* | 66.00* | 63.00* | 60.00* | 49.00$^{\#}$ |
| 60 | 0.0$^{ns}$ | 27.00* | 34.00* | 42.00* | 40.00* | 38.00* | 30.17$^{\#}$ |
| 70 | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| 80 | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| 90 | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| 100 | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| Mean | 0.00 | 43.55$^{@}$ | 52.18$^{@}$ | 60.45$^{@}$ | 57.45$^{@}$ | 55.27$^{@}$ | |
| LSD at 5% | Dust | 1.821 | Nematode inoculation | 2.468 | Interaction | 6.047 | |

**Table 9.** Effect of sawdust on number of egg mass of root-knot nematode on tomato plants.

| Sawdust concentration (%) | Inoculation levels | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 1000 | 2000 | 3000 | 4000 | 5000 | Mean |
| 0 | 0.0 | 37.0* | 48.0* | 60.0* | 57.0* | 52.0* | 42.33 |
| 10 | 0.0$^{ns}$ | 26.4* | 38.0* | 47.0* | 43.0* | 41.0* | 32.6$^{\#}$ |
| 20 | 0.0$^{ns}$ | 24.0* | 28.0* | 41.0* | 36.0* | 34.0* | 27.2$^{\#}$ |
| 30 | 0.0$^{ns}$ | 19.0* | 25.0* | 36.0* | 34.0* | 28.0* | 23.7$^{\#}$ |
| 40 | 0.0$^{ns}$ | 13.0* | 18.0* | 33.0* | 28.0* | 25.0* | 19.5$^{\#}$ |
| 50 | 0.0$^{ns}$ | 7.0* | 13.0* | 23.0* | 19.0* | 15.0* | 12.8$^{\#}$ |
| 60 | 0.0$^{ns}$ | 4.0* | 7.0* | 15.0* | 13.0* | 8.0* | 7.8$^{\#}$ |
| 70 | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| 80 | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| 90 | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| 100 | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| Mean | 0.00 | 11.9$^{@}$ | 16.1$^{@}$ | 23.2$^{@}$ | 20.9$^{@}$ | 20.4$^{@}$ | |
| LSD at 5% | Dust | 1.191 | Nematode inoculation | 1.612 | Interaction | 3.949 | |

* = data significant with 0 inoculation level & 0% dust concentration at *P*=0.05; ns = Not significant; # = data significant within a column at *P* = 0.05; @ = data significant in a row at *P* = 0.05.

**Table 10.** Effect of sawdust on fecundity of root-knot nematode on tomato plants.

| Sawdust concentration | Inoculation levels | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0** | **1000** | **2000** | **3000** | **4000** | **5000** | **Mean** |
| 0 | 0.0 | 405.0* | 417.2* | 432.0* | 428.4* | 424.0* | 351.10 |
| 10 | 0.0$^{ns}$ | 385.2* | 394.0* | 420.2* | 404.6* | 392.2* | 332.7$^{\#}$ |
| 20 | 0.0$^{ns}$ | 375.8* | 307.6* | 398.0* | 386.0* | 378.0* | 307.6$^{\#}$ |
| 30 | 0.0$^{ns}$ | 366.0* | 378.4* | 389.0* | 376.0* | 370.2* | 313.3$^{\#}$ |
| 40 | 0.0$^{ns}$ | 358.4* | 367.2* | 377.6* | 370.0* | 365.6* | 306.5$^{\#}$ |
| 50 | 0.0$^{ns}$ | 348.0* | 357.4* | 368.0* | 362.6* | 358.0* | 299.0$^{\#}$ |
| 60 | 0.0$^{ns}$ | 339.2* | 348.2* | 359.5* | 352.4* | 346.4* | 291.0$^{\#}$ |
| 70 | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |

**Table 10.** Contd

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 80 | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| 90 | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| 100 | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{ns}$ | 0.0$^{\#}$ |
| Mean | 0.00 | 234.3$^{@}$ | 233.6$^{@}$ | 249.5$^{@}$ | 243.6$^{@}$ | 239.5@ | |
| LSD at 5% | Dust | 1.690 | Nematode inoculation | 2.289 | Interaction | 5.570 | |

* = data significant with 0 inoculation level and 0% dust concentration at *P*=0.05; ns = Not significant; # = data significant within a column at *P* = 0.05; @ = data significant in a row at *P* = 0.05.

to become toxic for them. However, the reverse happens with egg masses and fecundity even at the same saw-dust levels which tend to remain in direct physical contact with the surrounding dust stressed environment. Other cause of their reduction was that of the development and colonization of nematode natural enemies (Oka, 2010; Thoden et al., 2011) in higher sawdust amendment soil. Increased colonization and reproduction of the nemato-phagous fungi was reported in sawdust amended soil (Hassan et al., 2010).

From the above discussion, we can conclude that saw-dust proved detrimental to overall root-knot disease of tomato plants. However, this dust improved growth and leaf pigments was about 30%.

## Conflict of Interests

The author(s) have not declared any conflict of interests.

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