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Effect of *Paecilomyces lilacinus* (Thom.) Samson on nutrient status and photosynthetic efficiency of banana inoculated with the root-knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood

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Abstract: An experiment was carried out to find out the effect of *Paecilomyces lilacinus* on leaf nutrient status, chlorophyll content and photosynthetic efficiency of banana cv. Robusta inoculated with the root-knot nematode, *Meloidogyne incognita*. Reducfion in nitrogen, phosphorus, potassium and magnesium and increase in calcium content of leaves in banana was noticed in the plants inoculated with *M incognita* which was directly proportionate to the population of nematodes and the leaf nutrient content was improved by the treatments with the biological agent namely *Paecilomyces lilacinus*. Highest P, K and Mg contents of 0.24, 4.29 and 0.79 per cent was recorded by the treatment *P. lilacinus* @ 30 g/kg of soil applied 60 days after planting which also registered the lowest Ca content of 1.05 per cent. The highest N content of 2.19. per cent was recorded in the treatment with Carbofuran 3G @ 40 g/plant applied at the time of planting. It was found that total chlorophyll and photosynthetic efficiency of leaves of banana decreased due to inoculation of *M.incognita*. The application of *P. lilacinus* improved the total chlorophyll and photosynthetic efficiency of infected banana plants which was directly proportionate to the dosage. Among the treatments, *P. lilacinus* @ 30 g kg^{-1} of soil applied 60 days after planting registered the highest chlorophyll content (7.697 mg/100 g tissue) and photosynthetic efficiency (0.2237 mg CO_2 /sec./m^2). *(Key words: Paecilomyces lilacinus, Meloidogyne incognita, Leaf nutrient, Photosynthetic efficiency, Total chlorophyll content).*

Banana is one of the important fruit crops in the tropics. It is the cheapest, plentiful and nourishing of all the fruits. It contains nearly all the essential nutrients including minerals and vitamins. It ranks second next to mango in area and production, occupying an area of 332.2 and 47.3 thousand hectares in India and Tamil Nadu respectively. Banana cultivation is highly affected by plant-parasitic nematodes. Nearly 34 genera of nematodes are found to be associated with banana in India. Among them, root-knot nematode, *Meloidogyne incognita* (Kofoid and White) Chi-wood is causing considerable yield loss even up to 60 per cent (Davide and Marasigan, 1992). It is evident that the chemicals used as nematicides are effective for the control of nematodes and to increase the productivity of the crop. At the same time, there is no doubt that the chemicals used for nematode control will end with problems such as health hazards, residual toxicity, pest resurgence and also adverse effect on beneficial microbes. Hence, a range of nematode management strategies has to be developed and biological control is one of such alternatives. Though it is possible to adopt chemical and non-chemical management strategies, biological control is bio friendly and economically feasible. Among the microbial agents, egg-parasitic fungus, *Paecilomyces lilacinus* (Thom.) Samson is very effective against nematodes of many horticultural crops (Sharma and Trivedi, 1989; Zaki, 1994). However, not much work has been carried out to find the effectiveness of *P. lilacinus* on leaf nutrient status, total chlorophyll content and photosynthetic efficiency of banana infected with *M.incognita*. In view of the above facts, a study was made to find out thc effect of *P. lilacinus* on leaf nutrient status, total chlorophyll content and photosynthetic efficiency of banana plants (cv. Robusta) inoculated with root-knot nematode, *M.incognita*.

Materials and Methods

The experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during 1995 in completely randomized block design with three replications. Uniform sized, healthy sword suckers of banana cv. Robusta were collected. They were trimmed to remove the outer

Table 1. Effect of *Paecilomvces lilacinus* on banana cv. Robusta inoculated with *Meloidogyne incognita*

Treatment	Population/ 200 cc soil	Egg masses/ 5g root	Nutrient Content (%)					Chloro-phyll (mg/100g)	Photo-synthetic efficiency (mg CO_2/ m^2)
			N	P	K	Ca	Mg		
T_1 *P.l* 10g/kg soil at planting	393 (2.594)*	15.7	1.97 (-10.0)	0.18 (-25.0)	3.93 (-8.8)	1.36 (+25.9)	0.50 (-36.7)	7.497 (-9.8)	0.1973 (-30.1)
T_2 *P.l* 10g/kg soil at 30 DAP	313 (2.496)*	16.3	1.92 (-12.3)	0.19 (-20.8)	3.73 (-13.5)	1.34 (+24.1)	0.55 (-30.4)	7.531 (-9.4)	0.1977 (-34.9)
T_3 *P.l* 10/kg soil at 60 DAP	272 (2.434)*	16.7	1.96 (-10.5)	0.19 (-20.8)	3.62 (-16.0)	1.39 (+28.7)	0.44 (-44.3)	7.527 (-9.5)	0.1979 (-34.8)
T_4 *P.l* 20g/kg soil at planting	203 (2.307)*	13.9	2.13 (-2.7)	0.20 (-16.7)	3.87 (-10.2)	1.23 (+13.9)	0.73 (-7.6)	7.563 (-9.0)	0.1994 (-34.4)
T_5 *P.l* 20g/kg soil at 30 DAP	197 (2.295)*	14.1	2.13 (-2.7)	0.19 (-20.8)	3.99 (-7.4)	1.21 (+12.0)	0.68 (-13.9)	7.571 (-8.9)	0.1991 (-34.5)
T_6 *P.l* 20g/kg soil at 60 DAP	190 (2.278)*	14.9	2.11 (-3.7)	0.22 (-8.3)	4.09 (-5.1)	1.24 (+14.8)	0.76 (-3.8)	7.570 (-8.9)	0.1997 (34.3)
T_7 *P.l* 30g/kg soil at planting	133 (2.124)*	9.1	2.13 (-2.7)	0.23 (-4.1)	4.21 (-2.3)	1.13 (+4.6)	0.76 (-0.1)	7.693 (-7.5)	0.2224 (-26.8)
T_8 *P.l* 30g/kg soil at 30 DAP	136 (2.133)*	10.5	2.17 (-0.9)	0.21 (-12.5)	4.26 (-1.20)	1.09 (+0.9)	0.79 (0.0)	7.697 (-7.4)	0.2227 (-26.7)
T_9 *P.l* 30g/kg soil at 60 DAP	123 (2.091)*	11.9	2.15 (-1.8)	0.24 (0.0)	4.29 (-0.4)	1.05 (-0.1)	0.79 (0.0)	7.697 (-7.4)	0.2237 (-26.4)
T_{10} Carbofuran 40g/plant at planting	203 (2.307)*	16.0	2.19 (0.0)	0.21 (-12.5)	4.27 (-0.9)	1.13 (+0.1)	0.73 (-7.6)	7.821 (-5.9)	0.2967 (-23.7)
T_{11} Untreated control	398 (2.600)*	23.0	1.93 (-11.9)	0.19 (-20.8)	3.70 (-14.2)	1.38 (+27.8)	0.47 (-40.5)	7.476 (-10.1)	0.1977 (-34.9)
T_{12} Uninoculated control	-	-	2.19	0.24	4.31	1.08	0.79	8.314	0.3039
CD (P=0.05)	0.221	1.5	0.21	0.02	0.39	0.11	0.06	0.397	0.0206

Figures in the parentheses are percentage increase (+) or decrease over uninoculated control
P.l - Paecilomyces lilacimus * Log x transformed values

layers and planted in 5 kg pots filled with autoclaved pot mixture (sand, red soil and farmyard manure in equal proportion) @ one per pot. A month after planting, the plants were inoculated with the root knot nematode *M.incognita* @ one nematode/g of soil. The effect of biological control agent namely *P. lilacinus* was observed by adopting the following treatments.

Treatment details:

T_1 - *P. lilacinus* @ 10g/kg of soil at planting

T_2 - *P. lilacinus* @10g/kg of soil at 30 days after planting

T_3 - *P. lilacinus* @10g/kg of soil at 60 days after planting

T_4 - *P. lilacinus* @20g/kg of soil at planting

T_5 - *P. lilacinus* @20g/kg of soil at 30 days after planting

T_6 - *P. lilacinus* @20g/kg of soil at 60 days after planting

T_7 - *P. lilacinus* @30g/kg of soil at planting
T_8 - *P. lilacinus* @30g/kg of soil at 30 days after planting
T_9 - *P. lilacinus* @30g/kg of soil at 60 days after planting
T_{10} - Carbofuran 3G @ 40g/plant at planting
T_{11} - Untreated control
T_{12} - Uninoculated control

Pure culture of *M incognita* was maintained on the banana cv. Robusta. The fungus *P. lilacinus* was cultured in test tubes with potato dextrose agar (PDA) and incubated at room temperature (28 ± 1°C) for 10 days. The fungus was then inoculated to the autoclaved sorghum grains in 500 cc Erlenmeyer flasks. The flasks were tumbled daily to maintain uniform growth of the fungus. After 14 days, one gram of grain was found to have 107 conidia.

Soil population of *M. incognita* per 200 cc soil and number of egg masses per 5 g root were estimated 150 days after nematode inoculation. Leaf samples from third leaf in the top from the banana plants were collected on 150th day after nematode inoculation. They were dried and analysed for nutrient contents. Total nitrogen in the leaf was estimated by microkjeldahl method. Phosphorus, potassium, calcium and magnesium contents in the leaf samples were estimated by preparing triple acid extract (Jackson, 1973) and the values were expressed in percentage. Nutrient contents in treatments were compared with uninoculated control. To estimate the chlorophyll contents, third leaf from plants at the time of termination of experiments were weighed and macerated in a homogeniser with 80 per cent acetone. The extract was centrifuged at 4000rpm for 15 minutes. The supernatant liquid was collected and adjusted to a known volume. The absorbance of extract was read in a spectronic 20 photoelectric colorimeter at 645 mn and 663 mn (Yoshida *et al.* 1971).Total chlorophyll content was calculated using formula given below and was expressed in mg/g leaf tissue.

Chlorophyll 'a' = 12.7 E 663 - 2.69 E 645
Chlorophyll 'b' = 22.9 E 645 - 4.68 E 663
Total chlorophyll = Chlorophyll 'a' + Chlorophyll 'b'

Photosynthetic efficiency in leaves was measured in photosynthetic efficiency meter and the value was expressed in mg $Co_2/s/m^2$. The data obtained from the treatments was subjected to statistical analysis following the procedure given by Gomez and Gomez (1984).

Results and Discussion

The changes in the leaf nutrients *viz.* nitrogen (N), phosphorous (P), potassium (K), calcium (Ca) and magnesium (Mg) of banana due to *M. incognita* and the treatments are presented in Table 1. Increase in Ca and decrease in N, P, K and Mg contents were found in plants inoculated with *M. incognita.* Nitrogen level decreased up to 12.3 per cent over uninoculated control in the treatment *P. lilacinus* 10 g kg^{-1} of soil applied at 30 days after planting. However, there was no reduction in the N content in carbofuran treated plants. Uninoculated control recorded N content of 2.19 per cent. Phosphorus content was reduced up to 25.0 per cent over the uninoculated plants in the treatment *P. lilacinus* 10 g kg^{-1} of soil at planting. Highest reduction of potassium (16.0 per cent) was recorded by *P. lilacinus* 10 g kg^{-1} of soil at 60 days after planting. *P. lilacinus* 30 g/kg of soil at 60 days after planting showed 0.4 per cent reduction which was the lowest. While the maximum increase of calcium content (28.7 per cent over uninoculated control) was found in plants treated with *P. lilacinus* 10 g kg^{-1} of soil at 60 days after planting. The plants treated with *P. lilacinus* 30 g kg^{-1} of soil at 60 days after planting showed 0.1 per cent decrease in calcium content when compared to the uninoculated control. Regarding Mg, the lowest content of 0.44per cent was detected in the treatment with *P. lilacinus* at 10 g kg^{-1} of soil at planting (44.3 per cent decrease over uninoculated control). No reduction was found in *P. lilacinus* (30 g kg^{-1} of soil) treated plants applied at 30 or 60 days after planting.

Changes in the chlorophyll content and photosynthetic efficiency of leaves due to *M. incognita* and the treatments are presented in Table 1.The reduction in the chlorophyll content and photosynthetic efficiency was directly proportionate to the population of *M. incognita* in soil and root. The lowest chlorophyll content of 7.476 mg/100g tissue was recorded by untreated plants (10.1 per cent decrease over uninoculated control) and the minimum reduction of 5.9 per cent was recorded by carbofuran treated plants

which registered 7.821 mg/100g tissue. Total chlorophyll content was found to be reduced by the inoculation of *M. incognita*. The treatment with *P. lilacinus* at 30g/kg of soil at 30 and 60 days after planting improved the total chlorophyll content to 7.696mg/100g tissue. The inoculation of *M. incognita* decreased the photosynthetic activity of the banana plants. The photosynthetic efficiency of leaves was reduced up to 34.9 per cent over uninoculated plants. Uninoculated control recorded the photosynthetic efficiency of 0.3039 mg $C0_2/s/m^2$. The treatment with *P. lilacinus* 3g/kg of soil at 60 days after planting improved the photosynthetic efficiency to 0.2967 mg CO_2 /s/m² (where as untreated plants recorded 0.1977 Mg $CO_2/s/m^2$).

Thus the present study revealed significant decrease in nutrient contents *viz.* nitrogen, phosphorus, potassium and magnesium and increase in calcium in leaves of banana inoculated with *M. incognita*. Increase in the nutrient concentration have been noted for the calcium (Goswami *et al.* 1976). Decrease in nitrogen, phosphorus (Heffes *et al.* 1991), potassium (Fataney and Evans, 1986) and magnesium (Ibrahim *et al.* 1984) has also been observed. These changes in the nutrient concentrations are contributing directly or indirectly to the chlorosis and the premature abscission of infected plants. These effects on the host increase with the level and duration of the infestation and along with the changes in other physiological processes such as photosynthesis, which in turn appear to be main cause of a lower yield in nematode infested plants. For example, the change in K concentration seems to be important because of its effect on photosynthesis either by affecting CO_2 uptake or by altering other key physiological process such as osmotic potential and increased calcium in shoot that delays fruit maturity (Ferguson, 1984)

In the present study, it was found that chlorophyll content and photosynthetic efficiency of leaves of banana decreased due to inoculation of *M. incognita*. Reduced photosynthesis due to nematode infested plants was also reported by earlier workers (Franco *et al.* 1981; Melakeberhan *et al.* 1984). Reduction in chlorophyll content of nematode infected plants is perhaps due to the obstruction in the uptake of water and nutrients by the affected root system.

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