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# Effect of Different Inoculum Levels of Nematode, *Heterodera avenae* on Photosynthetic Efficiency of Barley (*Hordeum vulgare* L.)

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Under present investigation effect of different inoculum levels of *H. avenae* on the rate of photosynthesis and water absorption capacity of barley variety RD 103 was evaluated. Photosynthetic efficiency of *Hordeum vulgare* in terms of Absolute Growth Rate (AGR), Relative Growth Rate (RGR), Net Assimilation Rate (NAR) and chlorophyll content was recorded in healthy and diseased plants of susceptible barley variety (RD 103) during growth periods of 30-60, 60-90 days. Total chlorophyll content and net photosynthetic rate decreased with increasing inoculum levels in diseased plants over their healthy control. Reduction in AGR was evident during growth periods of 30-60 and 60-90 at 10,000 inoculum level but in 90-120 days old plants even at the inoculum level of 100 juveniles per kg soil. Maximum decrease in RGR was noted at 10,000 inoculum level at all the growth periods over healthy checks. Similarly in 30-60 days old plants NAR was minimum at 10,000 inoculum level, whereas in 60-90 and 90-120 days old plants it was minimum at 1000 and 100 inoculum levels respectively.

**Key Words :** *H. avenae*, *Hordeum vulgare*, Absolute Growth Rate (AGR), Relative Growth Rate (RGR), Net Assimilation Rate (NAR), Chlorophyll, Photosynthesis etc.

## Introduction :

Nematode parasitism drastically alters host physiological process like photosynthesis and water absorption capacity that ultimately affect growth and productivity of the host plant. Many workers observed the effect of nematodes on photosynthesis, nutrient uptake and related physiological processes and the consequent impact on host productivity of annual crops (Loveys and Bird, 1973; Melakeberhan *et al*., 1987).

Sequential nature of plant response to nematode infection and the chain of events leading to reduced photosynthetic rate (Melakeberhan *et al*., 1985) a negative correlation between inoculum level of *Heterodera avenae* and chlorophyll, photosynthesis and mineral contents of wheat (Nagesh and Dhawan, 1988; Kaushal and Madavi, 1992); soyabean (Barker *et al*., 1989) were studied. Therefore, for the better understanding of the dynamics of host parasite relationship especially into physiology of the host plant (barley)

affected by *Heterodera avenae*, initiation on this direction is put forth under present studies.

## Material and Methods

Effect of different inoculum levels of nematode *Heterodera avenae* on photosynthetic efficiency of barley was examined. For this susceptible barley variety RD 103 were raised singly in 15 cm pots containing 1kg autoclaved soil and sand mixture (3:1). One week old seedlings were inoculated in a log series of 0,100,1000 and 10,000 active second stage juveniles of *H. avenae* in four replicates of the variety for each treatment. Uninoculated plants served as control. The photosynthetic efficiency was recorded in terms of Absolute Growth Rate (AGR), Relative Growth Rate (RGR) and Net Assimilation Rate (NAR) during the growth periods of 30-60, 60-90 and 90-120 days. For AGR, dry weights (PW1 and PW2) of aerial parts of plants at beginning and end of time intervals (t1 and t2) was calculated as below :

$$AGR = \frac{PW_2 - PW_1}{t_2 - t_1}$$

For RGR log values of the data were fitted in the formula

$$RGR = \frac{LogPW_2 - LogPW_1}{t_2 - t_1}$$

NAR was calculated with the formula :

$$\text{NAR} = \frac{\text{PW}_2 - \text{PW}_1}{\text{t}_2 - \text{t}_1} \times \frac{\text{Log}_e\ \text{La}_2 - \text{Log}_e\ \text{La}_1}{\text{t}_2 - \text{t}_1}$$

Where, $La_1$ and $La_2$ are the areas of foliage at the beginning and end of time intervals, $t_1$ and $t_2$, respectively.

The pigment contents i.e. chlorophyll a, chlorophyll b and total chlorophyll were estimated after 30,60 and 90 days following nematode inoculations as per the method of Arnon (1949). Fresh leaves of barley were washed, dried and one gram of each sample was crushed and homogenised

with 80% chilled acetone and a pinch of $MgCO_3$ powder in a mortar and pestle. The mortar pestle was kept in a cool place to avoid rise in temperature. Clear supernatant was decanted in test tube and residue was subject to grinding repeatedly with acetone unless it became colourless.

Acetone extracts then obtained were pooled together and centrifuged at 2000 rpm for five minutes. Volume of the clear supernatant thus obtained was made 50 ml by adding fresh acetone and stored in the flask. Optical density of the solution was read at 663 nm, 652 nm and 645 nm on spectrophotometer. The contents of different pigments were determined by following equations (Arnon, 1949).

$$\text{Mg/g tissue (Chl.a)} = [12.7 \times D_{663} - 2.69 \times D_{645}]\ V/1000 \times W$$

$$\text{Mg/g tissue (Chl.b)} = [22.9 \times D_{645} - 4.68 \times D_{663}]\ V/1000 \times W$$

$$\text{Mg/g tissue (Total chlorophyll)} = [20.2 \times D_{645} - 8.02 \times D_{663}] \times V/1000 \times W$$

or $D_{652} \times V/_{34.5} \times W$

Where, V = Volume of extract

W = Weight of the tissue

D = Represent the optical density of the chlorophyll extract at respective wavelength.

**Observations :**

The photosynthetic efficiency of *H. avenae* infected barley plants during growth periods of 30-60 , 60-90 and 90-120 days indicated decrease in all the three growth rates as compared to control plants (Table 1, 2). In 30-60 and 60-90 days old plants maximum reduction in AGR and RGR was observed at the inoculum level of 10,000 $J_2S$/kg soil, where as in 90-130 days plants maximum reduction in AGR even was evident at the inoculum level of 100 $J_2S$/kg soil and RGR of 10,000 $J_2S$ / kg soil , where as in 90-130 days plants maximum reduction in AGR even was evident at the inoculum level of 100$J_2S$/kg soil and RGR of 10,000 $J_2S$/kg soil.

Where NAR did not follow AGR and RGR trend, though NAR was minimum at the inoculum level of 10,000 $J_2S$/kg soil after 30-60 days, yet after 60-90 days and 90-130 days it was minimum at the inoculum levels of 1000 $J_2S$/kg and 100 $J_2S$/kg soil respectively. Per cent decrease in NAR was calculated

to be 46.1, 20.0 and 51.2 per cent after these three continuous time intervals (Table 1).

Data presented in table 2, exhibited reduction in chlorophyll content of diseased barley plants as compared to healthy check plants. Negative correlations was recorded between increase in inoculum level and total chlorophyll content. It was minimum in 30,60 and 90 days old infected plants at the highest inoculum level i.e. 10,000 $J_2$S/kg soil. There was increase in total chlorophyll content with increase in the age of the plant (Table 2).

**Discussion :**

Present study evidenced the adverse influence of cereal cyst nematode on the most important basic phenomenan of plant life i.e. photosynthesis of the host plant. Decline in photosynthetic activity of diseased plant was measured in terms of Absolute Growth Rate, Relative Growth Rate and Net Assimilation Rate that indicated possibility of nutrient stress which, consequentially suppressed plant growth. Suppression in vegetative and reproductive growth of wheat (Dhawan and Nagesh, 1987) and decrease in photosynthetic efficiency of wheat in terms of AGR, RGR and NAR due to *H. avenae* infestation was reported (Nagesh and Dhawan, 1988).

Reduction in growth rates may be due to partitioning of photosynthate by feeding and developing cyst nematode inside the host root. With an increase in nematode population, decrease in photosynthesizing area, closure of stomata, reduced efficiency of carbon fixation and decrease in dry weights suggested alteration in the growth pattern and decline in photosynthetic activity of infected plants same was suggested by Slatyer (1967) and Kramer (1983). Mc Clure (1977) suggested that in *Meloidogyne* infected plants significant amount of photosynthates diverted to the feeding site of the nematode. These changes may be attributed to a reduction in chlorophyll content (Magyarosy *et al*., 1976; Berghus and Reisener, 1985) and abnormalities in the structure and function of chloroplast (Montalbini and Buchanan, 1974).

Photosynthetic activity may also get altered due to changes in the water status of the crop due to obstruction of conducting tissues (Shtienberg, 1990). In water stressed plants the stomata remain closed, leading to a decline in $CO_2$ concentration in the substomatal spaces and in the mesophyll cell

**Table 1 . Effect of different inoculum levels of *Heterodera avenae* on photosynthetic efficiency of *Hordeum vulgare***

| Inoculum level ($J_2$S per kg soil) | Growth periods (Days after nematode inoculation) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30-60 | | | 60-90 | | | 90-120 | | |
| | AGR | RGR | NAR | AGR | RGR | NAR | AGR | RGR | NAR |
| 0 | 0.8330 | 0.0872 | 0.0026 | 0.0756 | 0.0072 | 0.0002 | 0.7358 | 0.0214 | 0.0039 |
| 100 | 0.1089 | 0.0567 | 0.0031 | 0.0594 | 0.0062 | 0.00056 | 0.1226 | 0.0109 | 0.0019 |
| 1,000 | 0.0802 | 0.0563 | 0.0018 | 0.0579 | 0.0110 | 0.00016 | 0.1566 | 0.0128 | 0.0028 |
| 10,000 | 0.0488 | 0.0482 | 0.0014 | 0.0280 | 0.0042 | 0.00019 | 0.1878 | 0.0107 | 0.0023 |
| Max. decrease over healthy control (%) | 94.1% | 44.7% | 46.1% | 62.9% | 41.6% | 20.0% | 83.3% | 50.0% | 51.2% |

(observation are mean of 4 replicates)

AGR = Absolute Growth Rate (mg $day^{-1}$)
RGR = Relative Growth Rate (mg $g^{-1}$ $day^{-1}$)
NAR = Net Assimilation Rate (mg $cm^{-2}$ $day^{-1}$)

**Table 2 . Effect of different inoculum levels of *Heterodera avenae* on chlorophyll content of *Hordeum vulgare* (barley) (Observations are mean of 4 replicates)**

| Inoculum level ($J_2$S per kg soil) | Growth periods (Days after nematode inoculation) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | After 30 days | | | After 60 days | | | After 90 days | | |
| | Ch.a | Chl.b | Total | Ch.a | Chl.b | Total | Ch.a | Chl.b | Total |
| 0 | 0.368 | 0.7240 | 1.0958 | 0.3904 | 0.7375 | 1.1475 | 0.3985 | 0.7432 | 1.1517 |
| 100 | 0.112 | 0.2274 | 0.3512 | 0.1305 | 0.1657 | 0.3516 | 0.1132 | 0.2116 | 0.3600 |
| 1,000 | 0.106 | 0.2258 | 0.3435 | 0.1187 | 0.1949 | 0.3449 | 0.1230 | 0.2063 | 0.3500 |
| 10,000 | 0.112 | 0.2226 | 0.3314 | 0.1307 | 0.1404 | 0.3353 | 0.1145 | 0.2257 | 0.3353 |
| Max. decrease over healthy control (%) | 71.1% | 69.2% | 69.7% | 69.5% | 80.9% | 70.7% | 71.5% | 72.2% | 70.8% |

that consequently reduced photosynthesis (Buchanan *et al*., 1981; Watson and Wardlow, 1981).

As water is one of the most important component of the photosynthate that initiates or acts as a reactant therefore, its stress directly affects rate of photosynthesis which in turn affect yield accumulation. Reduction in grain yield and poor quality grains were produced due to cereal cyst nematode infestion in barley plants. This can be attributed to decreased photosynthate capacity of barley plants.

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