STUDIES ON INTERACTION OF ROOT-KNOT NEMATODES AND ROOT-INFECTING FUNGI ON AIR POLLUTION STRESSED LEGUMINOUS CROPS.

ABSTRACT

Air pollution has entered as a new factor in agriculture. Crops grown around various kinds of industries are liable to be influenced since air quality is important for their growth and yield. Various kinds of gaseous or particulate air pollutants are now known to affect directly or indirectly agricultural crops. Research on this agricultural problem is relatively recent and new. Impacts of individual air pollutants or of their mixtures on growth and yield, physiology and structural configuration of various plant organs have been examined. The information available, though not adequate to make definite generalizations, suggest that air pollution in general is harmful for agricultural crops. A number of air pollutants have been shown to be suppressive for growth and yield of crop plants. Microorganisms, irrespective of their saprophytic, parasitic or symbiotic mode of life, associated with crop plants growing under pollution stress are likely to be influenced directly or indirectly through host-mediated effects. This aspect too has attracted attention of researchers. Information generated through these researches provides some indications. But at times, results are conflicting. Research on impact of air pollution on agricultural crops and associated microorganism, nevertheless, is in progress in different parts of the world.

Impact of air pollution on plant diseases caused by different groups of plant pathogens has also received some attention. Most researches are related to fungal diseases, especially on the foliage. Influence of air pollution on plant parasitic nematodes and diseases caused by them has also gained some study recently. In general, air pollution either enhances or suppresses the diseases of crop plants through its direct or host-mediated effects. This, however, depends on a number of factors, including the pathogen, type of the air pollutant, and its
concentration, exposure duration, kind of the crops etc. Considering the magnitude of air pollution and importance of agricultural crops across the world, the quantum of research done on this aspect is rather very meager. Interaction of root-infecting fungi and root-knot nematodes causing disease complexes on crop plants is well known phenomenon. This aspect of plant disease problem is likely to be influenced if the crop plants are growing under air pollution stress. Therefore, examining the influence of air pollution on interaction of root infecting fungi and root-knot nematodes, was the major objective of the present investigations.

In the present investigations, SO2, a common air pollutant in India, originating through burning of fossil fuels, particularly coal in thermal power plants, was selected for treatment (exposure) of the test plants in artificial conditions. Root-knot nematode, *Meloidogyne incognita* (race 1) and the wilt fungus, *Fusarium oxysporum* f.sp. *ciceri* and chick-pea were selected as test materials and studies were conducted in artificial exposure/inoculation conditions in glasshouse in order to determine individual impact of SO2. At the first instance, response of six cultivars of chick-pea viz., Pusa-209, Pusa-212, Pusa-244, Pusa-256, Pusa-267 and Pusa-436, which are grown in India by farmers, were examined against *M. incognita* (race 1) *F. oxysporum* f.sp. *ciceri* and SO2 using different inoculum levels/dosage. Inoculum levels of *M. incognita* were 0, 10, 100, 1000 and 10,000 J2 per pot and for wilt fungus 0.0, 0.5, 1.0 and 2.0 g of mycelium per pot. SO2 concentrations used for exposure of the test plants were 0.0, 0.1 and 0.2 ppm. Interaction of *F. oxysporum* f.sp. *ciceri* and *M. incognita* (race 1) was studied on two cultivars of chick-pea viz., Pusa-212 and Pusa-244 under glasshouse conditions. The inoculum levels of 2000 J2 of the nematode and 2.0 g mycelium of the fungus were used in this study. Similarly, impact of SO2 (0.2 ppm) on their interaction and interactive effects was also determined. The inoculum levels of the fungus and the nematode and the chick-pea cultivars were same as used in their interaction study. Effect of SO2 exposure on juvenile hatching of *M. incognita* and acidification of water was examined using micro-exposure cabinet. Effect of SO2 on colony growth of *F. oxysporum* f.sp. *ciceri* was also determined. SO2 was produced in a generator by reaction of Na2SO3 and H2SO4. Plants were
exposed in exposure chambers, made up of transparent fibre glass, every third day for three hours throughout the period of experiment. During the experimentation period, plants of various treatments were regularly examined for visible symptoms.

All the six cultivars of chick-pea included in the study were found to be susceptible to *Meloidogyne incognita* (race 1). Plant foliage and roots developed characteristic symptoms caused by root-knot nematodes. Significant reduction occurred in plant growth parameters (length of shoot and root and fresh and dry weights of shoot and root) at 1000 and 10,000 J2 inoculum levels of the nematode. The lower inoculum levels (10 and 100 J2) did not cause significant suppression in plant growth parameters of the chick-pea cultivars. Suppressions caused in plant growth parameters of the chick-pea cultivars were not equal. But all the cultivars were susceptible to the nematode, as the nematode caused root galling and egg masses developed on all the cultivars. Gall index (GI) was rated as 5 on all the cultivars at 1000 J2 and 10,000 J2 except Pusa-212 and Pusa-244 on which GI was 4 at 1000 J2. Egg mass index was 4 at 1000 J2 and 5 at 10,000 J2 on all the cultivars. Root-knot nematode infection suppressed root nodulation (number of root nodules per root system) of the cultivars. The suppression was related to the inoculum level of the nematode and the effect was more or less of the same intensity on each cultivar. The number of functional nodules declined and those of non-functional nodules increased by the nematode infection. These effects were also related to the inoculum level of the nematode. At 10 J2, *M. incognita* did not cause significant reduction in root nodulation. Numbers of functional and non-functional nodules were also not significantly affected at this inoculum level.

*Fusarium oxysporum* f.sp. *ciceri* caused reduction in plant growth of the cultivars. The extent of suppression varied among the cultivars and was related to the inoculum level of the fungus. All the cultivars were susceptible to this fungus. Pusa- 212, was, however, found to be resistant. Root nodulation on all the chick-pea cultivars found to be susceptible to the fungus. Maximum suppression occurred at the inoculum level of 2.0 g mycelium. Similar effect was observed in decline of the numbers of functional nodules. Non-functional nodules, how-
ever, showed an increase with increasing level of inoculum. Appearance of wilt symptoms on the susceptible cultivars was also dependent on the level of the inoculum. Higher level of the fungus inoculum induced early appearance and more severe wilt symptoms on the chick-pea cultivars.

Chick-pea cultivars exposed to sulphur dioxide exhibited chlorosis, intercostal necrotic patches and browning of the leaflet margins. Intensity and time of appearance of symptoms were SO$_2$ concentration dependent. At higher concentration (0.2 ppm) symptoms appeared earlier and were more severe than at the lower concentration (0.1 ppm). In general, plant growth of the chick-pea cultivars was suppressed by SO$_2$ which was greater at higher concentration. SO$_2$ also suppressed root nodulation on the chick-pea cultivars. The inhibition in the numbers of total and functional nodules was more at 0.2 ppm than in 0.1 ppm SO$_2$. Non-functional nodules increased as a result of SO$_2$ exposure, being greater at 0.2 ppm.

*Meloidogyne incognita* and *Fusarium oxysporum* f.sp. *ciceri* interacted synergistically causing greater suppression in plant growth of the chick-pea cultivars. Suppression was more when the nematode preceded the fungus (sequential inoculation) 3-weeks before the fungus than concomitant inoculation (inoculation of both pathogens at the same time). Interaction of both pathogens suppressed root nodulation and functional nodules and this effect was more under sequential than in concomitant inoculation. Conversely, non-functional nodules showed an increase due to interactive effect of the pathogens. Wilt symptoms appeared earlier with higher intensity under their association. Pusa-212, the cultivar of chick-pea which was found to be resistant to *F. oxysporum* f.sp. *ciceri*, developed wilt symptoms in the presence of the nematode. Hence, resistance of this cultivar against the wilt fungus was broken by the nematode.

Sulphur dioxide accelerated the appearance and severity of the symptoms produced by the nematode on chick-pea cultivars Pusa-212 and Pusa-244. When nematode-inoculated plants of the chick-pea cultivars were exposed to 0.2 ppm SO$_2$, suppression in plant growth parameters occurred. The growth suppressions
were greater than those caused by the nematode alone. Nematode-infected plants suffered greater growth losses than uninoculated plants. This trend was evident on both cultivars. SO₂ caused greater suppression of root nodulation. Decline in the numbers of functional nodules was also greater. SO₂, however, suppressed root galling and egg mass production by the nematode on the infected plants. Almost similar results were found when the fungus-inoculated plants were exposed to SO₂. Wilt symptoms appeared earlier on fungus-inoculated plants exposed to SO₂ than on plants inoculated with the fungus or fungus+nematode. Pusa-212, the wilt resistant cultivar, exhibited wilt symptoms after 30 days of exposure to SO₂. Therefore, its resistance to the fungal pathogen was broken by SO₂.

Maximum suppression in plant growth of chick-pea cultivars occurred when plants inoculated with both the pathogens were exposed to SO₂. Similar effects were noticed on root galling and egg mass production by the nematode. Suppression of root nodulation and numbers of functional nodules were significantly greater in the presence of all the three pathogens in comparison to other treatments. Appearance of wilting was further advanced and intensity increased when nematode+fungus inoculated plants were exposed to sulphur dioxide.

Sulphur dioxide inhibited juvenile hatching of *Meloidogyne incognita* and this suppression increased with an increase in the concentration of SO₂. The water pH also gradually decreased as the number of exposure and concentration of SO₂ increased.

Sulphur dioxide also suppressed colony growth of the wilt fungus which was greater at 0.2 ppm SO₂. However, at 0.05 ppm SO₂ slight increase in growth of the fungus occurred which was, however, not significant statistically.

The study, first of its kind, suggests that SO₂ as air pollutant can accelerate pathogenesis and enhance pathogenic effects of root-knot nematodes and wilt-causing fusaria on susceptible crops. The interaction between wilt-causing fusaria
and root-knot nematodes may be influenced by SO\textsubscript{2} causing crop losses greater than those caused by their interaction. SO\textsubscript{2} stress can also break resistance of crop cultivars against wilt causing fusaria. Air pollution, caused by SO\textsubscript{2}, therefore, may enhance the pathogenic damage to crops both under monopathogenic or multipathogenic situations. Benefit derived by leguminous crops through symbiotic nitrogen fixation by root nodule bacteria would also be greatly reduced. Similar effects can be expected for other gaseous air pollutants. It is likely that crops grown under air pollution stress, around various industries, may be experiencing such adverse effects. Extensive studies involving various plant parasitic nematodes and wilt-causing fungi, different crops and their cultivars under varying air pollution stresses are needed to evaluate the dimensions of the problem and magnitude of the crop losses.