J. Phytol. Res. **24**(2) : 155-160, 2011

MINERAL NUTRIENTS RESPONSE OF WHEAT AND SORGHUM TO FOLIAR APPLICATION OF SOME CHEMICALS

M. B. KANADE and V. S. SHIRASHYAD*
Department of Botany, Tuljaram Chaturchand College, Baramati, Dist. Pune- 413102, India.
*Department of Botany, Walchand College of Arts & Science, Solapur - 413006, India.
E-mail : mahadevkanade@yahoo.com

Present investigation based on effect of salicylic acid, potassium, allopurinol and their combination on mineral contents in rust susceptible wheat var. 'Agra local' and sorghum var. 'M 35-1'. The enhanced level of sodium, potassium, calcium, manganese, magnesium, iron, zinc, copper, cobalt, molybdenum and phosphorus due to foliar application above chemicals clearly suggest that one can employ these chemicals to induce defence mechanism.

Keywords : Allopurinol; Minerals; Potassium; Salicylic acid; Sorghum; Wheat.

Introduction

The minerals are omnipresent and are important constituents of living systems at all levels. According to Agarwal *et al.*[1] micronutrients play an important role in improvement of plant metabolism which results into increase in growth parameters. Potassium is a typical example of a mineral nutrient that exerts its regulatory function by changing the conformation of the protein component of the enzymes. The alternative environmental friendly method to control the diseases through balanced mineral nutrition and developing host plant resistance through metabolic defense mechanism is utmost important. Susceptibility of crop plants largely depends upon imbalances of mineral nutrition. The ionicimbalance during pathogenesis has been confirmed by many workers[2].

Especially micronutrients when applied as foliar spray exert pronounced influence on plant growth and yield, which in some respects resembles those of growth regulators. Such micronutrients have been used as a tool for improving the growth and yield of crop plants[3].

Insecticides and fungicides are sometimes applied in conjunction with plant nutrients. As such combined application is thought to increase the efficiency of pesticides in protecting the growing plants from infestation with insects and attack of fungal diseases along with avoiding adverse side effects. Such treatments were shown to increase yield, improve quality and raise tolerance to disease. Many workers[4-6] have studied plant disease control by fungicides with nutrients *viz.* molybdenum, boron, phosphorous, copper, Zinc etc.

Based on forgoing literature survey, in the present investigation an attempt has been made to study the effect of foliar application of salicylic acid (SA), potassium (K) and allopurinol individually as well as in combination (synergistic) on highly susceptible wheat variety "Agra local" to rust and locally grown sorghum variety "M 35-1".

Material and Methods

The surface sterilized seeds of wheat var. 'Agra local' and sorghum var. 'M 35-1' were sown in an earthen pots containing soil mixed with farm yard manure in the proportion of 3:1 and sterilized by treating with 5% formalin to kill the soil borne fungal pathogens. Wheat (8 plants / pot) and sorghum (3 plants / pot) were raised in natural light (166 $\mu Em^{-2}s^{-1}$) with temperature 30±2°C and 19±2°C day-night and were kept free from diseases and pests.

The aqueous solutions of allopurinol (50μM), SA (50μM) and K (200 ppm) individually and combined in the equal volume of all the three chemicals and mixing in the proportion of 1:1 with distilled water were used for foliar application. Fifteen days old plants were sprayed with respective chemicals individually and in combination for 5 times at an interval of 8 days upto drain-out point at 10 am using manually operated air pneumatic spray pump. The control plants were sprayed with equal amount of distilled water. These plants were analysed for inorganic constituents.

Mineral constituents were analysed from acid digested plant extract performed as per the method of Toth *et al.*[7]. 1g dried plant sample was acid digested firstly with

20 ml concentrated nitric acid on hot plat till the solid particles get dissolved and then with 15 ml perchloric acid till the solution become colourless. After cooling, the volume was made to 100 ml with distilled water and kept overnight. It was then filtered and the filtrate was used for analysing different mineral elements *viz.* Na, K, Ca, Mn, Mg, Fe, Cu, Zn, Co and Mo on Atomic Absorption Spectrophotometer (Perkin Elmer - 3030).

The phosphorous content was estimated according to the method of Sekine *et al.*[8]. 4 ml acid digests extract taken in a test tube and to this 2 ml 2N HNO_3 followed by 1 ml Molybdate Vanadate Reagent were added. The final volume of each test tube was adjusted to 10 ml with distilled water. The ingredients were mixed well and allowed to react for 20 min. The colour intensity was measured at 420 nm using a reaction blank containing no phosphorous.

Results and Discussion

The observations of effect of foliar application are recorded in Table 1. According to Mengel and Kirkby[9] sodium contributes to the osmotic potential of the cell and thus has a positive effect on the water regime of plants. Singh[10] reported that sodium is useful in controlling various fungal, bacterial and viral diseases. As such according to Levitt[11] the increased amount of sodium content may help in maintaining ionic balances thereby it get accumulated in the diseased site. Increase in amount of sodium in the diseased tissue has also shown by Khare and Lakpale[12].

The level of sodium greatly influenced in all the treatments as compared with that of control. The maximum stimulation was observed in case of wheat than that of sorghum. Among the three chemicals, allopurinol application exhibited high level of sodium uptake in the leaves of both plants. The synergistic treatment showed increase in the level of sodium uptake both the plants with slight variation whereas in all the other treatments, the level of sodium was comparatively more in wheat than sorghum.

From the present data it appears that SA and allopurinol mainly contribute in maintaining ionic balance by way of enhancing sodium uptake. The increased level of sodium in wheat and sorghum can be attributed to the development of disease resistance by way of maintaining ionic balance.

Potassium is a vital plant nutrient and no other nutrient can replace it. It is univalent cation essential for all living organisms and is highly selective and closely coupled to metabolic activity. It is mainly concern with osmoregulation and stomatal movement, protein synthesis, photosynthesis, enzyme activation and also plays an important in development of disease resistance.

The K uptake studied in the leaves of wheat and sorghum was found to be almost similar in all the treatments and maximum being noted in K applied plants. Another interesting point observed over here is that the K uptake was more in all the treatments than that of control plants.

Many workers have reviewed the various functions of K in plants. K not only influences crop production by enhancing growth and synthetic processes but it is also highly important in raising the disease resistance of crop species[13]. Besides it promotes turgidity to maintain internal pressure of crops and increase disease resistance in plants. According to Suelter[14] K functions as a catalyst of numerous enzymes, and there are more than 50 enzyme which either completely depend on or are stimulated by K. Edwards[15] concluded that there is yield loss in crops due to K deficiency. Thus enhanced level of K in wheat and sorghum due to foliar application of K may be useful as a safeguard in protecting the plants from infection.

Calcium is a relatively large divalent mineral element well known for detoxifying higher concentrations of other mineral elements in plants[16]. It is highly essential nutrients for almost all the plants. Calcium functions in plants are associated with membranes, cell walls, a few enzyme reactions, phytohormone regulatory reactions, osmoregulation, pollen tube growth and cell division[17]. It also plays an important role in development of resistance in plants and hence analysed.

The calcium uptake studied in the present investigation was found to be more in both wheat and sorghum in all the treatments but the maximum uptake was noticed in sorghum than that of wheat compared with control. Among all the three chemicals allopurinol favored calcium uptake.

There are reports that the calcium content of plant tissue affects the incidence of parasitic diseases. According to Platero and Tejerina[18] the resistance of plants is closely related to their calcium content. Calcium is required as a secondary messenger for certain processes in plant defence mechanism[4].

Enhanced level of calcium uptake in the present investigation due to foliar application of SA, K and allopurinol in wheat and sorghum, led us to surmise that possibly these chemicals stimulate the transpiration stream there by absorb more calcium which inhibit the activity of polygalacturonase a pectoloytic enzyme normally secreted by the pathogen for their systemic spread.

Table 1. Effect of salicylic acid, potassium, allopurinol and their combination (synergistic) on mineral contents in wheat var. 'Agra local' and sorghum var. 'M 35-1'.

Mineral contents	Control		Salicylic acid (50 µM)		Potassium (200 ppm)		Allopurinol (50 µM)		Synergistic (1:1)	
	Wheat	Sorghum	Wheat	Sorghum	Wheat	Sorghum	Wheat	Sorghum	Wheat	Sorghum
Sodium	0.046	0.029	0.061	0.036	0.058	0.031	0.067	0.049	0.054	0.045
Potassium	3.18	2.99	4.49	4.36	7.74	6.65	4.57	4.15	5.02	3.92
Calcium	0.508	0.874	1.054	1.386	0.913	1.400	1.375	1.615	1.183	1.399
Manganese	0.0037	0.0038	0.0042	0.0054	0.0040	0.0051	0.0051	0.0060	0.0040	0.0049
Magnesium	0.191	0.251	0.225	0.337	0.250	0.318	0.299	0.404	0.260	0.312
Iron	0.120	0.151	0.130	0.195	0.127	0.175	0.154	0.184	0.137	0.164
Zinc	0.176	0.195	0.254	0.294	0.368	0.300	0.520	0.454	0.510	0.404
Copper	0.0034	0.00273	0.0049	0.00604	0.0044	0.00347	0.0054	0.00739	0.0050	0.00415
Cobalt	0.00034	0.00012	0.00037	0.00024	0.00038	0.00027	0.00040	0.00034	0.00050	0.00035
Molybdenum	0.0014	0.0021	0.0025	0.0038	0.0035	0.0041	0.0039	0.0060	0.0032	0.0055
Phosphorus	0.197	0.189	0.201	0.210	0.207	0.201	0.227	0.329	0.215	0.261

Values are expressed in g/100 g dry weight

Thus these chemicals can be employed in developing disease resistance in wheat and sorghum. The detailed study of a pectolytic enzyme polygalaturonase in response to SA, allopurinol and K coupled with calcium may through more light in chemical manipulation in development of rust resistance.

Manganese (Mn) is one of the highly essential micronutrients in plants and is absorbed in its active from as Mn^{2+} in plants. The role of manganese in activating various enzymes viz. IAA oxidase, decarboxylase, dehydrogenases of TCA cycle and in superoxide dismutase[19] are very well known. Besides there are reports that manganese deficiency can increase susceptibility of pathogen invasion[20].

This observation prompted us to study the Mn content in the leaves of wheat and sorghum under the influence of foliar application of allopurinol, SA and K individually and synergistically. The data represented reveals that the Mn content in crops increases in response to foliar application of the above chemicals. The maximum stimulation in Mn uptake was noticed in allopurinol treated plants followed by SA treatment. In the two crops sorghum exhibited more Mn uptake than that of wheat.

The literature survey pertaining to response of Mn in disease resistance indicates that, Mn nutrition affects soil borne fungal and bacterial diseases in various ways. Graham *et al.*[21] reported that more that 100 diseases in different crops can be controlled by micronutrients and further mentioned that manganese alone control about 50 diseases of different crops. In the present investigation the wheat var. 'Agra local' selected for the experimental purpose is highly susceptible to rust, similarly the sorghum var. 'M 35-1' exhibit rust symptoms at the late periods of its growth. Under these circumstances the chemicals such as allopurinol, SA and K, which stimulate the uptake of Mn be certainly helpful in developing control strategy against rust pathogen.

Like that of Mn, magnesium (Mg) is most important, mobile, strong electropositive and abundant divalent element of plants. It is a major constituent of chlorophyll and also present in ribosome and proteins[22]. There is a long list of enzyme reactions where magnesium work as a cofactor and play important role in the control of certain fungal diseases6 and hence this element was analysed.

The Mg content studied in wheat and sorghum in response to foliar application of allopurinol, SA and K is represented in Table 1. It is very clear from the results that, the allopurinol and SA favour Mg uptake to greater extent than that of K application and the combined application of all the three chemicals. Here also the maximum uptake of Mg was noticed in sorghum that that of wheat. In wheat the stimulation of Mg uptake is in the order of SA < K and < allopurinol, while in sorghum var. 'M 35-1' the maximum uptake of Mg was noticed in allopurinol treated plants followed by SA treated one.

Hiremath *et al.*[6] while studying role of magnesium on disease resistance and its relationship with

productivity potential in groundnut reported that the application of $MgSO_4$ @ 50 kg/ha and magnesite 250 kg/ha significantly reduced the incidence of late leaf spot and rust. The magnesium application also increases the osmotic potentials of cells. From this observation they concluded that the magnesium acts through increased synthesis of chlorophyll and osmoregulation.

In the present investigation we observed that the chemicals such as allopurinol, SA and K favour magnesium uptake. This observation led us to conclude that these chemicals help in induction of disease resistance in wheat and sorghum by way of increasing Mg content in the leaf tissue.

Iron (Fe) content represented in Table 1 indicated that, SA and allopurinol application stimulate Fe uptake in sorghum, that K and the synergistic application. On the other hand Fe uptake was stimulated more in wheat due to application of allopurinol. None of the chemicals used in the present investigation exhibited reduction in Fe uptake below the level of control, which clearly indicate that all the chemicals appears to be beneficial for Fe uptake in wheat and sorghum.

The literature survey reveals that iron availability affects induction of systemic resistance of *Fusarium* wilt of radish by *Pseudomonas flurescens*[23]. Press *et al.*[5] showed the role of iron in *Rhizobacteria* induced systemic resistance to cucumber. According to them decreased content of iron may be due to utilization by the pathogen from its pectin enzyme system. The stimulation of Fe uptake in response to SA, allopurinol and K in wheat and sorghum in the present investigation indicate the efficacy of these chemicals in indication of disease resistance.

Zinc (Zn) plays an important role as an essential trace element in development, growth and differentiation in all living organisms[24]. It is a component of more than 200 enzymes isolated from different species where it is indispensable to their catalytic function and structural stability[25]. Thus the Zn can truly be called as an element without which no life is possible and hence analysed.

The results (Table 1) showed maximum uptake of Zn both in wheat and sorghum in response to allopurinol application and in synergistic application of all the three chemicals. The application of SA and K also stimulated Zn uptake over control but the degree of stimulation was at lower ebb than that of allopurinol and synergistic application. From the data it can be concluded that these chemicals trigger the uptake of Zn and this stimulated Zn level may help in minimizing the disease development in wheat and sorghum.

The copper (Cu) uptake appeared to be stimulated in response to all the chemicals used for foliar application on wheat and sorghum but the maximum stimulation was found in SA and allopurinol applied plants. Among the two plants sorghum exhibited more uptake of Cu in allopurinol and SA treatments whereas wheat exhibited more uptake of Cu in K application and in synergistic application.

The action of copper as a fungicide release on direct application to the plant surface. At least in wheat the copper nutritional status dose not significantly affect the rate of infection by powdery mildew, with severe deficiency of copper however, the development of adult plant resistant to powdery mildew was inhibited[26]. Thus looking to the data of present investigation, it can very well be said that the enhanced uptake of copper in response to allopurinol and SA application may help in regulation of rust resistance.

The cobalt (Co) content analysed from the leaves of wheat and sorghum under the influence of SA, K and allopurinol depicted in Table 1. All these chemical applications triggered the level of cobalt. The maximum Co uptake was found in synergistic application followed by allopurinol, K and SA. Among these two plants the response of wheat to cobalt uptake appeared better than that of sorghum.

The involvement of cobalt in many metabolic processes is very well known. Cobalt induced increase in the growth and nitrogen content of the shoots of nodulated plants was also reported[27]. Besides, cobalt plays an important part in oxidative phosphorylation and the structural and functional organization of leaves[28] and in this respect the presence of cobalt in leaf tissue may help in developing disease resistance by contributing in structural organization of leaves, which needs further investigation.

Molybdenum (Mo) is a very rare element and is an essential micronutrient for plants, animals and microorganisms[29]. The plants requirement of Mo is very low[30]. But nevertheless, Mo deficiency has been reported for many plant species including herbs, crops and trees. And is mainly caused due to the lack of nitrate reductase catalyzing step in nitrate assimilation[31].

Its uptake studied in wheat and sorghum under the influence of SA, K and allopurinol was greatly influenced but the maximum uptake was observed in allopurinol applied plants. The synergistic effect of these chemicals however, showed reduction in the uptake of Mo as compared to rest of the chemicals but this reduction was not gone down below the level of control.

The role of Mo in disease is not known but it

plays an important role in nitrate reductase. Generally the increase in wheat and looking to the increased Mo uptake in wheat due to these chemical applications one can speculate that the nitrogen content can be reduced by the action of nitrate reductase, which may help in minimizing rust infection. However, it is too early, to guess this assumption, unless one confirms it. This needs further investigation.

The disease control through nutrient management is a novel approach and hence the alternative environment friendly methods of disease control through balanced mineral nutrition and developing host plant resistance, through metabolic defence mechanism is utmost important.

Phosphorus is a nutrient for plants and microorganisms second in importance only to nitrogen. An interesting aspect of this element is its favourable effect on the symbiotic association between plants and some soil fungi[32,33]. According to Newhook and Podger[34] little leaf disease of exotic conifers caused by *Phytophthora cinnamomi* is essentially a reflection of nutrient deficiencies which is corrected by single application of phosphatic fertilizer. Besides, its deficiency, leads to a general reduction of most metabolic processes, including cell division and expansion, respiration and photosynthesis[35].

Taking in to consideration the role of phosphorus in disease resistance, it was analysed in the leaf tissue of wheat and sorghum under the influence of foliar applied salicylic acid, potassium and allopurinol. The data depicted in Table 1 indicates good response of phosphorus uptake in sorghum under the influence of allopurinol application. The synergistic effect no-dought showed stimulation of uptake in sorghum, it was less than that observed in allopurinol application. The response of wheat to these chemicals in absorbing phosphorus appeared to be less than that of sorghum. The data clearly indicates that phosphorus uptake stimulate more due to allopurinol application in both plants.

The foliar aprays of NPK fertilizer on induction of systemic protection against *Puccinia sorghii* and growth enhancement in maize was studied by Reuveni *et al.*[36]. Similarly high and low concentrations of boron, calcium, copper, iron, magnesium, manganese, molybdenum, potassium was studied to establish relationship of mineral nutrient status with leaf spot disease in *Ficus elastica*[37]. Whereas Chandrashekhar *et al.*[38] studied the effect of foliar spray of potassium on the leaf spot disease of groundnut.

From the foregoing literature survey it is crystal clear that the micronutrients play a pivotal role in establishment of disease resistance. The effort made in the present investigation to examine micronutrient uptake under the influence of the chemicals like allopurinol, salicylic acid and potassium, which are one or the other way employed in developing the disease resistance against rust, appeared to be on the proper track. As such the wheat var. `Agra local` selected for the present investigation is highly susceptible to the rust infection. Thus the nutrient level influenced by these chemicals will certainly beneficial for development of control strategy against rust.

References

1. Agarwal S C, Nautiyal B D and Chatterjee C 1986, Manganese, copper and molybdenum nutrition of papaya. *J. Horti. Sci.* **61** 397-405.
2. Dube H C and Gaur H N 1977, Permeability alteration of rust and leaf spot of *Lucerne* and tikka disease of groundnut. *Symposium on Physiology of Microorganism* 235-248.
3. Sakal R and Singh A P 2001, Micronutrients in relation to yield response and quality of crops. *Indian J. Agric. Chem.* **34**(1-2) 1-13.
4. Sanders D, Brownlee C and Harper J F 1999, Communicating with calcium. *The Plant Cell* **11** 691-706.
5. Press C M, Loper J E and Kloepper J W 2001, Role of iron in *Rhizobacteria* mediated induced systemic resistance of cucumber. *Phytopathol.* **91** 593-598
6. Hiremath S M, Kalpana M, Chetti M B and Suryavanshi A 2003, Role of magnesium on disease resistance and its relationship with productivity potential in groundnut. *2nd International Congress of Plant Physiology,* Jan. 8-12, New Delhi, India.
7. Toth S T, Prince A L, Wallace A and Mickelson D S 1948, Rapid quantitative determination of eight mineral elements in plant tissue by systematic procedure involving use of flame photometer. *Soil Sci.* **66** 459-466.
8. Sekine T, Sasakawa K, Morita S, Kimura T and Kurolemi K 1965, *Photoelectric Colorimetry in Biochemistry,* Part 2. Namko-do Publishing Co., Tokyo, 242.
9. Mengel K and Kirkby E A 1982, *Principles of Plant Nutrition.* Int. Potash Inst. Bern, Switzerland.
10. Singh P 2000, Permeability changes and mineral metabolism in the leaves on onion infected with *Alternaria porri. Ad. Plant Sci.* **13**(1) 323-325.
11. Levitt J 1972, *Response of plant to environmental stress.* Academic press, New York and London.
12. Khare N and Lakpale N 1997, Changes in mineral contents of soybean leaves infected by *Xanthomonas compestris* Pv. *Glycines. Ad. Plant Sci.* **10**(2) 271-

273.

13. Matocha J E and Smith L 1980, Influence of potassium on *Helinthosporium cynodontis* and dry matter yields of coastal Bermudagrass. *Agron. J.* **72** 565-567.
14. Suelter C H 1976, Enzymes activated by monovalent cations. *Science* **168** 789-795.
15. Edwards N 2000, Why potassium may reduce cereal leaf disease. *Cereals : Crop Uptakes,* 2000.
16. Marshner H 1986, *Mineral nutrition of higher plants.* Academic press, Harcourt Brace Jovanvich Publishes, London.
17. Schmit J N 1981, *Acad. Sci.* Ser III, **293** 755-760.
18. Platero M and Tejerina G 1976, Calcium nutrition in *Phaseolus vulgaris* in relation to its resistance of *Erwinia carotavora. Phytopathology Z.* **85** 314-319.
19. Elstner E F 1982, Oxygen activation and oxygen toxicity. *Annu. Rev. Plant Physiol.* **33** 73-96.
20. Graham R D 1983, Effect of nutrient stress on susceptibility of plants to disease with particular reference to trace elements. *Adv. Bot. Res.* **10** 222-276.
21. Graham R D, Webb M D and Huber D M 1991, Micronutrients and diseases. *Bulletin of Indian Micro-fertilizer Manufactures Association* **12** 1-3.
22. Cammarano P, Felsani A, Gentile M, Gaulerzi C, Romeo C and Wolf G 1972, Formation of active hybrid 80-S particles from subunits of pea seedlings and mammalian liver ribosomes. *Biochem. Biophys. Acta* **281** 625-642.
23. Leeman M, DenQuden F M, VanPelt J A, Dirkx F P M, Steijl P A, Bakker H M and Schippers B 1996, Iron availability affects induction of systemic resistance to *Fusarium* wilt of radish by *Pseudomonas flurescens. Phytopathol.* **86** 149-155.
24. Srivastava S, Choudhary R and Joshi N 1999, *Advances in Microbial Biotechnology,* APH Publ. Co., New Delhi.
25. Eide D 1998, *Metal ions in gene regulation,* Chapman and Hall, New York.
26. Graham R D 1980, Susceptibility to powdery mildew of wheat plants deficient in copper. *Plant Soil* **56** 181-185.
27. Powrie J K 1964, The effect of young *Lucerne* on a siliceous sand. *Plant Soil* **21** 81-93.
28. Loercher L and Liverman Y L 1964, Influence of Co on leaf expansion and oxidative phosphorylation. *Plant Physiol.* **39** 720-725.
29. Fortescue J A C 1992, Landscape geochemistry : retrospect and prospect, 1990. *Applied Geochem.* **7** 1-53.
30. Gupta U C 1997, *Molybdenum in Agriculture.* Cambridge : Cambridge University Press.
31. Mendel R R and Hansch R 2002, Molybdoenzymes and molybdenum cofactor in plants. *J. Expt. Bot.* **53**(375) 1689-1698.
32. Lamb R J and Richards B N 1974, Inoculation of lines with mycorrhizal fungi in natural soils. I. Effects of density and time of application of inoculums and phosphorus amendments on mycorrhizal infection. *Soil Biol. Biochem.* **6** 167-171.
33. Lamb R J and Lambeth V N 1975, Effect of controlled release fertilizers on blossom - end to incidence in *Lycopersicon esculentum* cv. *Patio hybrid. Hort. Sci.* **10** 17-18.
34. Newhook F J and Podger F D 1972, The role of *Phytopathora cinnamomi* in Australian and New Zealand forests. *Annu. Rev. Phytopathol.* **10** 299-326.
35. Terry N and Ulrich A 1974, Effects of magnesium deficiency on the photosynthesis and respiration of leaves of sugar beet. *Plant Physiol.* **54** 379-381.
36. Reuveni M, Agapov V and Reuveni R 1996, Controlling powdery mildew caused *Sphaerotheca fuliginea* in cucumber by foliar sprays of phosphate and potassium salts. *Crop Protection* **15** 49-53.
37. Marlatt R B and Orth P G 1970, Relationship of potassium to a leaf spot of *Ficus elastica.* 'Decora'. *Phytopathol.* **60** 255-257.
38. Chandrashekhar V, Narayanaswami R and Rambadran R 1994, Effect of foliar spray of potash and neem seed extract on the tikka leaf spot of groundnut. *Indian Phytopathol.* **47**(2) 188-189.