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Effect of Edaphic Factors on Groundnut Stem Rot Development

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ABSTRACT

Pot culture experiments were conducted at Department of Plant Pathology, Agricultural College, Bapatla to find out the effect of edaphic factors like, soil type, soil pH and soil moisture on ground nut stem rot development. The highest stem rot incidence was in sandy soil (94%) and the lowest was in black soil (6.7%) which did not significantly differ with the incidence in red soil (8.4%). Soil moisture at 40 MHC was found optimum for stem rot development with the highest incidence (95.8) than at lower (20 MHC) and higher (80 MHC) levels. Soil pH between 5.0 and 8.0 allowed stem rot development though higher incidence was at lower pH of 6.0 (89.1) followed by 5.0 (82.3). At pH 8.0 stem rot incidence was 39.1%.

Key words: *Groundnut, pH, Soil moisture and Pot culture, Stem Rot*

Groundnut (*Arachis hypogaea* L.) is widely distributed in tropics, subtropics and also warm temperate regions of the world and is one of the important oilseed crops of the world. Groundnut oil is known to contain resveratrol, a polyphenol antioxidant, that reduces the risk of cancer, heart disease, degenerative nerve disease and viral infections. (Kumar *et al.,* 2013). Groundnut is cultivated in more than 100 countries of the world in an area of 22.23 M ha and production of 34.55 M t. However, the productivity of groundnut in Andhra Pradesh is only a third of national average. Groundnut productivity is affected by several abiotic and biotic stresses, edaphic factors like soil type, soil moistutre, soil pH *etc*. that influence plant growth, production and also play key role in encouraging the micro flora that may be beneficial or deleterious to the groundnut crop. Among various biotic stresses that hamper groundnut production, stem rot caused by *Sclerotium rolfsii* Sacc. greatly influences the yield. It is known as Sclerotium blight, Sclerotium rot, Sclerotium wilt, southern blight, southern stem rot, root rot, white mould and pod rot. The pathogen can survive 3-4 years in soil as sclerotia formed by the pathogen and results in 25-80% yield loss with severe infections at the condition of intensive inoculum level. (Porter *et al.,* 1984)

MATERIAL AND METHODS

To know the type of soil that favors stem rot disease development, a pot culture experiment was conducted with three types of soils viz. sandy soil, red soil and black soil and two combinations *viz*., red and sand mix (1 part red soil and 9 parts sand) and black and sand mix (1 part red soil and 9 parts sand). Six kg capacity earthen pots were used to fill the test soils and sterilize with four per cent formalin where pots were covered with polyethylene bags for seven days, after that polyethylene bags were removed and allowed for complete escaping of fumes for three days. Fifteen days old culture grown on sorghum grains was mixed thoroughly with soil upto five cm at four per cent (w/w basis). Healthy surface sterilized groundnut seeds were sown in pots. Plants in pots without inoculum served as control. Five replications were maintained for each soil type.

Effect of soil moisture on stem rot disease development was conducted at the condusive soil moisture levels for stem rot infection by the pathogen. Water holding capacity of the soil was determined by Keen's cup method. The radius and depth of keen box was measured with a vernier caliper. The dish of the keen's cup was cleaned, dried and weighed. Whatman No.1 and 44 filter paper were cut and placed at the bottom of the keen cup. The air-dried soil was passed through a 2 mm sieve and was filled in the boxes by repeated tappings (20-30 timing). The surface was leveled and was weighed. The cup was placed in the soaking tray and gradually filled with water from the side till the water level was about 1 cm above the base of the cup. The tray was covered to prevent evaporation from soil surface and it was kept for 12 h or more for equilibrium. A continuous and shining film of water at the soil surface confirmed this. The cup is carefully removed from the water and wiped dry from outside and weighed quickly. The expanded soil (above cup's rim) is cut off with spatula and was transformed to previously weighed watch glass. The watch glass is weighed with expanded out wet soil. The soil of watch glass and keen cup is dried in the oven at 105^0 C and constant weight is recorded. A blank test (only with keen cup and filter paper) was also run simultaneously to find the weight of the water absorbed by the filter paper alone. Soil moisture holding capacity was determined by using the following

$$\text{Water holding capacity} = \frac{\text{Wet weight of the soil} - \text{Oven dry weight of the soil}}{\text{Oven dry weight of the soil}} \times 100$$

Plastic pots of 1.5 kg capacity were selected and wiped with spirit and dried for some time. Sterilized soil was taken into pots and thirty days old culture grown on sorghum grains was mixed thoroughly with four per cent (w/w basis). Five healthy surface sterilized groundnut seeds were sown in each pot. Plants in pots without inoculum served as control. Different soil moisture holding capacities (MHC) of soil viz. 20, 40, 60, 80 MHC were maintained by adding sterilized water on weight basis throughout the period. Five replications and two pots sown five seeds per pot and each replication were maintained for each MHC.

Effect of soil pH on stem disease development was carried out using plastic pots of 1.5 kg capacity filled with sterilized soil and thirty days old *S. rolfsii* culture grown on sorghum grains was mixed thoroughly at four per cent (w/w basis) with the top soil. Five healthy surface sterilized groundnut seeds were sown in each pot. Plants in pots without inoculum served as control. Initial soil pH was measured and it was 8.17. Different soil pH level 5.0, 6.0, 7.0 and 8.0 were prepared by potentiometric titration method. The amount of acid added to the soil was determined by drawing a curve through potentiometric titration by taking one kilogram of soil sample and known quantities of 1N HCl was added (0, 5, 10, 15, 20 and 25 ml) in duplicates. Further, 1000 ml of water was added to these soil samples and kept for 3-4 days with periodical stirring. After equilibration 400 ml distilled water was added and pH was measured. A curve that plots ml of 1N HCl per kg soil and the resulting pH was drawn. Based on this curve, amount of acid required to obtain required soil pH was calculated. The soil in the study was maintained at 60 per cent moisture holding capacity (MHC) by adding required quantity of double distilled water every day. Five replications were maintained for each pH level and each replication contained two pots sown with five groundnut seeds. Experiment for the edaphic factors was conducted in Completely Randomized Design. In all the three experiments number of stem rot infected plants was counted and per cent disease incidence was computed.

RESULTS AND DISCUSSION

Groundnut in Andhra Pradesh is cultivated in soils of different types *viz.* sandy, red and loamy soils. Soil type was found to have no profound bearing on groundnut seed germination. However, sandy soil or a mixture of sandy soil with black or red clay soils favoured groundnut seed germination than black and red clay soils alone.

Stem rot incidence in inoculated soil was recorded at five dates at weekly interval starting 33 DAS at which the highest disease incidence was in sandy soil (22.9%) followed by red + sandy (22.4%) and black + sandy soils (23.6%) which were on a par with each other. The lowest disease was in black soil (6.7%) which did not significantly differ with the incidence in red soil (8.4%). (Table 1)

Disease progressed with passage of time in soils of all types. However, incidence increased more rapidly in sandy soil, red + sandy soil and black + sandy soil. At subsequent observations also the highest incidence was in sandy soil followed by red + sandy and black + sandy soil. At the final observation on 61 DAS, the highest incidence was in sandy soil (94%) was on a par with that of sandy + red and sandy + black soils. However, incidence in red soil was significantly more than that in black soil in the last three observations. (Table 1)

Physical properties of soils of different types could be the reason for development of the *S. rolfsii* and the resultant disease incidence. Sandy soils and light textured soils under optimum soil moisture conditions provide better aeration to this strictly aerobic organism and did not offer much resistance to its growth and spread which might have led to higher incidence. Secondly, the pathogen might have encountered greater resistance from a more frequent surface microflora in heavier soils which were more and diverse than in light soils. Sclerotia of *S. rolfsii* from nonsterile soils were reported to germinate poorly which was corroborated by the finding that treatment with sodium hypochlorite enhanced germination of sclerotia from non sterile soils (Punja and Grogan, 1981; Punja *et al*., 1984**)**. Srujana *et al*. (2014) found greater and diverse *Pseudomonas fluorescens* populations in heavier soils than in light soils. The lesser disease incidence in heavier soils thus could be attributed to greater microbial activity. These findings reinforce the results of Thilagavathi *et al.* (2013) who found that sandy loams were conducive to root rot and stem rot in sugarbeet caused by *S. rolfsii* whereas while clayey soils were suppressive because of dominant actinomycete population.

Groundnut seed germination (90 to 92%) was not affected by soil moisture level ranging from 20 to 80 MHC at increments of 20 MHC. Disease incidence recorded at 15 days interval starting from 31 DAS up to 59 DAS showed increase with passage of time. At 31 DAS, the highest incidence recorded at 40 MHC was on a par with that of 60 MHC. There was no

Table 1: Effect of soil type on stem rot disease development

Soil Type	Germination (%) 9 DAS	Disease Incidence (%)				
		33 DAS	40 DAS	47 DAS	54 DAS	61 DAS
Sandy	96.0 (82.6)	22.9 (28.5)	29.3 (32.6)	46.0 (42.6)	71.1 (57.9)	94.0 (81.0)
Red	94.0 (78.9)	8.4 (13.0)	12.7 (18.5)	34.0 (35.5)	57.6 (49.4)	74.4 (59.7)
Black	92.0 (77.3)	6.7 (11.7)	6.7 (11.7)	13.2 (19.0)	24.6 (29.2)	35.6 (36.4)
Red + Sandy	98.0 (86.3)	16.4 (23.6)	22.4 (28.2)	40.9 (39.7)	71.6 (57.9)	90.0 (75.7)
Black + Sandy	98.0 (86.3)	14.2 (21.6)	18.2 (24.8)	34.7 (36.0)	63.6 (53.0)	88.0 (72.0)
SEM	4.4	3.7	3.6	3.0	2.8	4.6
CD	NS	10.9	10.6	9.0	8.2	13.5
CV (%)	12.0	42.1	34.6	19.7	12.6	15.8

Date of sowing: 17-07-2014

Table 2: Effect of soil moisture on stem rot disease development

MHC	Germination (%) 10 DAS	Disease Incidence (%)				
		31 DAS	38 DAS	45 DAS	52 DAS	59 DAS
20	90.0 (75.7)	6.5 (11.5)	15.2 (22.8)	21.9 (27.7)	33.2 (35.1)	49.1 (44.5)
40	92.0 (75.3)	26.0 (30.6)	48.0 (43.8)	65.3 (54.2)	80.9 (64.8)	95.8 (82.4)
60	92.0 (77.3)	23.9 (29.2)	39.1 (38.6)	41.3 (39.9)	57.4 (49.4)	72.4 (58.7)
80	90.0 (73.6)	8.9 (15.6)	20.1 (26.5)	20.1 (26.5)	28.8 (32.3)	33.5 (35.2)
SEM±	5.0	3.2	1.9	2.7	3.3	3.1
CD	NS	9.6	5.6	8.2	9.9	9.4
CV (%)	14.7	33.1	12.6	16.5	16.4	12.7

Date of sowing: 18-07-2014

Table 3: Effect of soil pH on stem rot disease development

Soil pH	Germination (%) 9 DAS	Disease Incidence (%)				
		30 DAS	37 DAS	44 DAS	51 DAS	58 DAS
5	88.0 (72.0)	13.4 (19.1)	24.9 (29.9)	38.3 (38.1)	52.2 (46.3)	82.3 (67.8)
6	86.0 (70.7)	17.9 (24.7)	31.5 (33.9)	42.7 (40.7)	56.1 (48.5)	89.1 (72.9)
7	88.0 (72.0)	16.4 (23.5)	23.2 (28.4)	34.1 (35.5)	46.1 (42.7)	73.7 (59.8)
8	86.0 (70.7)	11.2 (17.3)	20.4 (26.4)	36.6 (37.1)	39.1 (38.6)	66.7 (54.9)
SEM±	5.2	3.9	2.7	2.5	2.3	4.5
CD	NS	NS	NS	NS	6.8	NS
CV (%)	16.4	41.0	20.4	15.0	11.5	15.7

Date of sowing: 01-10-2016

DAS = days after sowing NS = non significant
Figures in parentheses are arcsine transformed values

significant difference in the lowest disease incidence at 20 MHC and 80 MHC. (Table 2)

Thirty eight days after sowing, the stem rot incidence trends at different moisture levels followed the same pattern as in the previous observation. However, at 45 DAS incidence at 40 MHC was significantly more than at other MHC. The highest and the lowest MHC of 40 and 80 slowed down the progress of incidence. The trend continued at 52 DAS and 59 DAS also but the incidence levels were substantially and significantly greater at 40 MHC. The highest incidence at the last observation *i.e.,* 59 DAS, was at 40 MHC was 95.8% while the least was at 80 MHC (33.5%) which did not significantly differ with that at 20 MHC (49.5). (Table 2)

It is evident from these findings that *S. rolfsii* could survive, develop and cause stem rot at the moisture levels studied but the incidence level is influenced by moisture level. Soil moisture at 40 MHC followed by 60 MHC favoured stem rot development the most and the two extremes tested in this study though allowed infection were less favourable. Moisture is essential for growth and sclerotial germination at an optimum level. Lesser moisture level was reported to support lesser sclerotial production and germination. High soil moisture level expectedly reduced growth, and sclerotial production and germination obviously for conditions of hypoxia which is detrimental to this predominantly aerobic organism.

Soil moisture at 40 to 50 MHC was found congenial for *S. rolfsii* sclerotial viability. Higher saprophytic colonization of groundnut substrate by *S. rolfsii* in soil at 25 MHC than at 50 and 75 MHC was found (Latha *et al.*, 2006) perhaps due to unaccounted residual moisture in groundnut substrate which might have led to higher moisture than was actually intended. Bowen (2003) recorded more frequent stem rot hits in irrigated groundnut fields than in rainfed fields indicating greater spread of sclerotia in the field and sustaining optimum soil moisture favourable to the fungus. Fluctuations in soil moisture were found to enhance sclerotial germination leading to higher plant kill (Beute and Rodriguez-Kabana, 1979) perhaps moisture stress could have weakened the plant and the facultative parasite might have hastened their death.

Groundnut seed germination did not differ significantly at the four pH levels in this study and ranged between 86 and 88%. Stem rot incidence was observed at all pH levels but higher incidence was at lower pH of 6.0 followed by 5.0 regardless of the date of observation which however did not differ significantly except at 51 DAS. The highest incidence at this date was 89.1% at pH 6.0 which was on a par with incidence at pH 5.0 and 7.0 but significantly higher than at pH 8.0 (39.1%). At the last date of observation also a similar trend in disease incidence at the pH levels tested was observed. However, incidence though was substantially higher at lower pH was not significant from the incidence at higher pH. (Table 3)

Sclerotium rolfsii is an oxalic acid producing fungus and uses the acid in its infectivity of plants (Punja, 1985; Prabhu and Patil, 2005; Shukla and Pandey, 2007) and also perhaps as a niche capturing tool by altering the pH of the substrate to its advantage. Soil or substrate or medium pH was found a primary determinant in many biological events of *S. rolfsii viz*., growth, sclerotial production, survival and germination, and causing infection in host plant (Mathur and Sarbhoy, 1976; Chattopadhyay and Mustafee, 1977; Jadon and Tiwary, 2011; Zape *et al*., 2013). (Table 3)

The findings are in conformity with those of previous workers as higher mortality due to *S. rolfsii* infection was observed at pH ca. 5.0 or 6.0. Shim and Starr (1997) reported higher infection at pH 5.6 and decreasing deaths at increasing soil pH. Groundnut substrate colonization by *S. rolfsii* was found favoured by pH in the range of 4.0 and 6.0 (Latha *et al.*, 2006). Soil pH at 6.1 caused the highest death of clusterbean plants and an increase in pH up to 8.4 was found to significantly decrease mortality (Singh and Gandhi, 1991).

Sclerotium rolfsii secretes cell wall degrading enzymes and the importance of cellulase (Cx) in pathogenesis was emphasized by Bateman (1969). Ambient pH was found to play a key role in the enzymatic activity of cellulase and polygalacturonase. Higher activity of cellulase at lower pH (Toorray *et al.*, 2005) could have resulted in higher disease incidence in this study.

Barring a few reports, sclerotial production and germination were mostly suppressed at pH > 7.0 (Aycock, 1966: Punja and Grogan 1982; Punja, 1985) which might lead to no or very less incidence of stem rot in peanuts and other plants. However, in this study and that of Shim and Starr (1997) sclerotial germination and infection of groundnut plants did occur at pH > 8.0 albeit lesser, probably due to a similar signaling and activation of a *pacC/RIM1* homolog as in the related fungus *Sclerotinia sclerotiorum*, when the ambient pH was alkaline that might have triggered secretion of oxalic acid resulting in reduction of pH and subsequent production of sclerotia and infection of groundnut plants (Rollins and Dickman, 2001).

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