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Effect of Biotic and Abiotic Stresses on Shisham (*Dalbergia sissoo* Roxb.) Mortality in Bihar

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Abstract The present study was carried out in all the selected districts of North Bihar to observe the shisham mortality due to biotic and abiotic factors. During the study 30-40% areas of district were covered and three distinct types of disease symptoms were noticed i.e. sudden, slow/yellowing and partial wilting of shisham tree. Highest disease incidence and mortality in shisham were recorded in Katihar district (81.4 and 56.9%) followed by Araria (78.2 and 52.3%) however, lowest disease incidence and mortality were recorded in Darbhanga (38.1 and 19.5%) followed by Khagaria (43.0 and 22.0%). The maximum disease incidence and mortality (61.8 and 46.8%) was recorded in plant having girth regimes 51-100 cm followed by (49.3 and 42.5%) plants having 101-150 cm girth. The maximum disease incidence and mortality were noticed in waterlogged areas (72.0 and 55.0%) followed by semi-flooding (49.9 and 32.7%). The waterlogged condition highly aggravated the disease incidence and mortality of shisham. It was also noticed that younger trees with lesser girth regimes more susceptible to disease than older and higher girth regimes trees. The maximum dominance of pathogen was recorded from bark of infected shisham tree (90-100%) followed by lateral root (40-80%). The dominance of pathogen was minimum in rhizosphere soil *Fusarium solani* f. sp. *dalbergiae* has been confirmed as the pathogen causing shisham wilt in North Bihar.

Keywords *Dalbergia sissoo,* Mortality, Symptomatology, Stresses, *Fusarium solani* f. sp. *dalbergiae.*

Introduction

The shisham (*Dalbergia sissoo* Roxb.) is one of the most important multipurpose tree species of India as well as most recognized world wide. The species is also cultivated in Nepal, Bhutan, Bangladesh, Myanmar, Malaysia, Pakistan, Afghanistan and countries in tropical – subtropical Africa. In Arizona and Florida states in USA, it is said to be one of the most desirable shade trees for streets and backyards. It is used for production of timber, fuel, wood, fodder, medicine and honey in social forestry plantations and agroforestry systems. The wood is durable and extremely strong. Shisham is valuable component of inter-cropping system in north and eastern India, where they are popular with small scale resource limited farmers because of their versatility. Shisham plays an important role in soil and water conservation though, in natural forests, usually diseases remain under control due to genetic diversity and ecological variations. In India, Tarai region of the country and North Bihar are considered as natural zone of shisham

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plantation. It suffer from many diseases that include leaf spot, leaf blight, powdery mildew, rust, root rot, bud rot, canker, stem (wood) rot, root knot nematode, physiological disorder. Shisham mortality is further aggravated by various edaphic and environmental factors like water-logging, drought, soil salinity, soil nutrition, rainfall, extreme temperatures and pathogen have been attributed. However, shisham mortality gradually taking the shape of epidemics and causing loss to farmers [1]. In recent past, large scale mortality of shisham has been recorded in different parts of India. Besides the biotic causes, a number of stress factors such as changing climatic conditions, water-logging, longer dry spell, root injury, soil compaction, salt accumulation and improper plantation sites have been correlated with shisham mortality [2].

In Bihar, the shisham mortality was first time noticed during 1995, in East and West Champaran district, when few farmers reported sudden death of shisham tree (Partial/whole) in their field. Further this problem was reported from all over Bihar [3]. In a survey report in Bihar, an area of 8400 km^2 stretching from the fertile gangetic plains to Tarai grasslands, bordering Nepal was found affected by shisham mortality. They isolated the organism associated with wilt and reported that *Fusarium solani* f. sp. *dalbergiae* was the major cause of wilt/mortality [1]. The present paper dealt with disease distribution, symptoms, factors affecting and pathogen associated with shisham (*Dalbergia sissoo* Roxb.) mortality in North Bihar.

Materials and Methods

The present study was conducted in 17 shisham mortality affected district of Bihar for two consecutive years from 2005-2006 and 2006-2007 in rainy seasons. The survey was conducted in all districts covering 30 to 40% areas in each selected district using hundred meter transacts along with linear plantation on road, canals and river embankments and sampling (10 × 10 m quadrates) for assessment of shisham mortality under block plantation and different agro-forestry systems. Abiotic stress condition viz. water logging, flooding, semi-flooding, degraded soil and high density plants were also recorded during survey. The samples of plants parts as well as rhizosphere soil samples of infected, alive and dead shisham trees samples were collected and analyzed. The visual symptoms, percent disease incidence and mortality were recorded during study. On the basis of plant girth regimes, the infected trees under all stress condition were categorized into 0-50, 51-100, 101-150, 151-200, 201-250, 251-300 and 301-350 cm (circumference at breast height) classes. Rhizosphere soil sample of infected shisham trees were also analyzed for pH and EC measured in 1:2 soils water suspension. For identification of pathogen, the root parts of affected shisham were cut into 1 mm pieces of approximately and surface sterilized in 0.1 % mercuric chloride solution for 1 minute. The cut pieces were washed throughly in sterilized water to remove the disinfectant and transferred aseptically on potato dextrose agar medium (PDA) in petridishes. The incubated petridishes were incubated at 26 ± 1^0C for 72 h for production of sufficient mycelia. The growing hyphal tip was cut and transferred aseptically to fresh PDA slants to obtain pure culture.

For confirming the pathogenicity, the root system of 1-3 years old standing shisham plant werew injured with knife inside the soil and drenched with spore suspension of 10^6 conidia of *F. solani* f. sp. *dalbergiae* per ml sterilized distilled water. Then the root system of inoculated plants was covered in collar region by polythene sheets for 48 h to maintain humidity in root zone. Uninjured plants werte also inoculated and maintained for comparison for proving Koch's postulates.

Results and Discussion

Disease incidence

The data depicted in the Table 1 revealed that the maximum disease incidence and mortality was observed in all selected districts of North Bihar. Maximum disease incidence and mortality was recorded in Katihar district (81.4 and 56.9%) followed by Araria (78.2 and 55.4 %). However, lowest disease incidence and mortality was recorded in Darbhanga district (38.1 and 19.5%) followed by Khagaria (43.0 and 22.0%). The analysis of soil indicated that soils of the districts were moderately alkaline in nature (pH 8.1-8.4) with low in salinity (EC 0.62-0.69 dS/m). There was no distinct relationship were observed between disease incidence and soil properties. These finding are in

Table 1. Disease incidence and mortality % of shisham tree in different districts of Bihar. Figures in parentheses (%) incidence and mortality.

Districts	Area covered (km^2)	No of trees observed	Disease incidence (%)	Mortality (%)
		2005-2006		
Samastipur	15.0	1470	715 (48.6)	515 (35.0)
Muzaffarpur	20.0	1350	641 (47.4)	440 (32.5)
Darbhanga	17.0	1200	458 (38.1)	234 (19.5)
Madhubani	15.0	1100	660 (60.0)	256 (23.2)
Vaishali	10.0	1310	816 (62.2)	531 (40.5)
East Champaran	15.0	1750	1075 (61.4)	796 (45.4)
West Champaran	18.0	1633	955 (58.4)	691 (42.3)
Gopalgang	18.0	1575	1024 (65.0)	748 (47.4)
		2006-2007		
Madhepura	13.0	1120	756 (67.5)	526 (46.9)
Saharsa	17.0	1070	696 (65.0)	455 (42.5)
Supoul	15.0	1365	962 (70.4)	676 (49.5)
Araria	12.0	1630	1276 (78.2)	904 (55.4)
Purnea	15.0	1425	1055 (74.0)	745 (52.2)
Katihar	18.0	1525	1242 (81.4)	869 (56.9)
Khagaria	16.0	1100	473 (43.0)	242 (22.0)
Begusarai	11.0	1275	644 (50.5)	319 (25.0)
Sitamarhi	14.0	1372	796 (58.0)	553 (40.3)

accordance with the result of earlier workers [1] where they have observed that there was no distinct relationship between percent infection and pH and EC. This finding also support the finding of Bajwa and Javaid [4], they observed that maximum mortality of up to 80% was recorded in canal bank followed by 20-40% along with highways and roadsides.

Symptomatology

During the survey three distinct type of disease symptoms were notice viz. sudden wilting, yellowing/slow wilting and partial wilting. The characteristic features of disease symptoms were explained below.

Sudden wilting symptom

The green leaves observed sudden wilting tendency with complete droping of leaves and dry from upward within 15-20 days. After 20-25 days dried leaves detached from branches (Fig. 1a). The branches start drying from top and plant dried within 3 months. Some times after leaf defoliation, new small leaves and some new branches (apical bud) appear on the plants, but within 3-4 months again wilting symptoms appear. Such plants died within 2-3 months after second infection.

Slow wilting / yellowing symptom

Such types of symptoms were mostly observed in upland plantation as compared to low land and water-logged plantations. First, green leaves turn yellow slowly from top of the plant and defoliation occurs down ward. Branches start drying from top to bottom and plant completely die within 9-12 months (Fig. 1b).

Partial wilting symptom

Few branches or few portion of plant die and remaining portion of plant were alive. Sometimes wilting start from top and half height of tree died and remaining portion alive for a longer period even upto 2-3 years for complete plant drying (Fig. 1c).

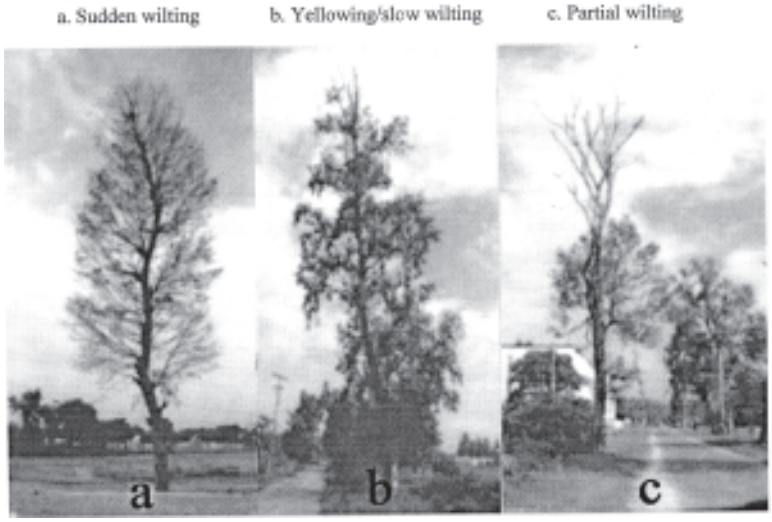
Factors responsible for disease development

Plant girth

During the course of study, it was observed that the younger trees were more affected than the older ones; therefore, the disease incidence in different girth regimes was studied. Result indicated that maximum disease incidence of 61.8% and mortality 46.8% were noticed in plant having 51-100 cm girth regimes followed by 49.3 and 42.5% having girth regimes 101-150 cm. Plant having girth regimes 201-250 and 251-300 cm showed 2.9 to 2.0% disease incidence and mortality, respectively Table2. The results confirmed the earlier findings of Dayaram et al. [1], Bajwa and Javaid [4]. The mortality rate of shisham along highways was also fairly high ranging from 20-40%. The least mortality and disease incidence of 10% or below was observed on shisham trees growing on agricultural land [5].

Abiotic factors

As regards the factors of abiotic stress i.e. water-



a. Sudden wilting b. Yellowing/slow wilting c. Parting

Fig. 1. Three distinct type symptoms of shisham plants wilting.

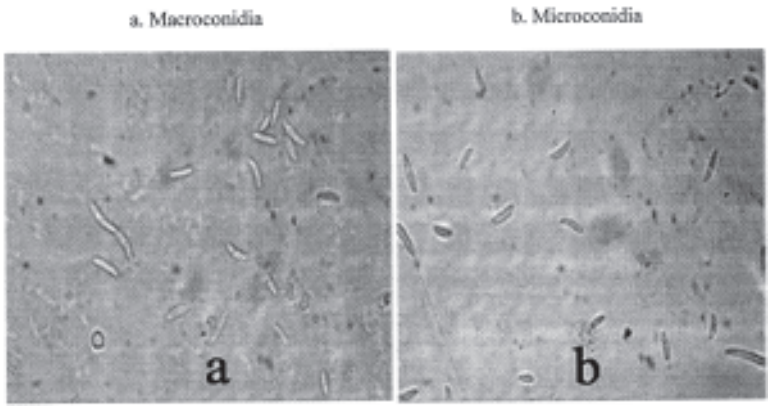
logging, flooding, semi-flooding, degraded soil and high density of plant were also study for mortality test. The data in Table 2 indicated that maximum disease incidence and mortality was observed in water-logging areas (72.0 and 55.0%) followed by semi-flooding (49.9 and 32.7%). Minimum disease incidence and mortality were recorded in degraded soil (25.1 and 11.5%) followed by flooding (28.8 and 19.1%). It might be due to anaerobic condition prevailing due to flooding of soil causing damage of plant root system. The high density of plant coupled with degraded soil causing mortality of shisham plant in the study areas. The result confirmed the earlier findings of Dayaram et al. [1] reported that water-logging, flooding, semi-flooding, degraded soil and high density plants support the wilt incidence and mortality in shisham. Similar finding have been also reported earlier [6, 7], they observed that water-logging was found to intensify the decline the sissoo mortality.

Pathogenicity

The analysis of soil and plant samples revealed that dominance of *Fusarium solani* f. sp.*dalbergiae* (Fig. 2a and 2b macro and micro conidia) was found in the study areas. The pathogen was isolated in all types of samples i.e. rhizosphere soil, feeder root, lateral root and bark of infected shisham tree. The maximum dominance of pathogen *Fusarium solani* f. sp. *dalbergiae* was recorded from berk (90-100%) followed by lateral root (40-80%) and rhizosphere soil (25-75%).These findings are in conformity with the

Table 2. Effect of different abiotic stresses for development of disease and shisham mortality. Figures in parentheses indicates number of plants under study.

Abiotic stress factors	Area covered (km^2)	No of trees observed	Diseaee incidence (%)	Mortality (%)
Water-logging	15.0	1122	72.0 (808)*	55.0 (445)
Flooding	19.0	1011	28.8 (292)	19.1 (56)
Semi-flooding	13.0	1072	49.9 (535)	32.7 (175)
Degraded soil	6.0	1203	25.1 (303)	11.5 (35)
High density	9.0	1007	39.0 (393)	21.1 (83)
Plant girth (cm)				
0.50	25.0	720	18.0 (130)	8.46 (11)
51-100	27.0	703	61.8 (435)	46.8 (204)
101-150	35.0	652	49.3 (322)	42.5 (137)
151-200	29.0	611	4.0 (25)	8.0 (2)
201-250	22.0	547	2.9 (16)	2.9 (16)
251-300	15.0	598	2.0 (12)	2.0 (12)
301-350	24.0	509	1.9 (10)	1.9 (10)



a. Macroconidia b. Microconidia

Fig. 2. *Fusarium solani* f. sp. *dalbergiae* (10x).

earlier findings [1], [8–10]. During pathogenicity tests symptoms were more pronounced after 30 days of inoculation, the leaves showed yellowing of top leaves. Subsequently the diseased leaves complete drying and defoliation of leaves occurred. The plant completely died within 90-100 days after inoculation. Color of stem changed from green to light brown/ dark. However, in artificial inoculation wilting symptoms were somewhat different.

On the basis of above findings it may be concluded that *F. solani* f. sp. *dalbergiae* is the pathogen causing mortality of shisham under North Bihar areas. The abiotic factor like water-logging prevail in all the districts of North Bihar aggravated disease incidence and mortality of shisham. However, incidence of disease and rate of mortality was related to age group and girth regimes of shisham plant.

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