ADDRESSING PEST AND DISEASE CHALLENGES IN THE NATIONAL FOREST PLANTATIONS: LESSONS LEARNED FROM THE NATIONAL FOREST HEALTH FORUM

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ABSTRACT

This paper presents the results of the work carried out by the National Forest Health Forum (NFHF), which covered five National Forest Plantations: Mbizi (Sumbawanga), Meru/Usa (Kilimanjaro), Meru (Arusha), Shume (Tanga) and Sao Hill (Iringa) for the period of five years (May, 2012 - July, 2017). The problems addressed are diseases caused by pathogens and those caused by inadequacies of various requirements from the soils. Many of the diseases have been soil-borne which gave rise to foliar symptoms, with Armillaria root rot being in the lead. Occasionally, the ravage by insect pests was encountered at Sao Hill and Meru Forest Plantations. These problems threaten the productivity of the plantations against the objective for the plantations of supporting the much needed industrialization process. To a large extent, these problems which were recorded in the visited plantations were noted to be accelerated by two phenomena namely; climate change and taungya. Therefore, this paper describes the problems addressed in the plantations; the steps adopted in addressing them, key findings and recommendations for achieving better plantations.

Keywords: Forest diseases, soil-borne pathogens, insect pests, National Forest Health Forum.

INTRODUCTION

The formation of the National Forest Health Forum (NFHF) was one of the outcomes of TAFORI workshop held at Kibaha Conference Centre (KCC) in Kibaha in February, 2011. In this workshop, about 40 technical personnel from public and private institutions gathered to discuss matters hampering productivity and sustainability of the National Forest Plantations. Some of the Institutions involved were Forestry and Beekeeping Division (FBD), Tanzania Forestry Research Institute (TAFORI), Sokoine University of Agriculture (SUA), Tropical Pesticides Research Institute (TPRI), Tanzania Tree Seed Agency (TTSA), Forestry Training Institute (FTI), Kilombero Valley Teak Company (KVTC) and Green Resources. At the midst of the joint discussions was the unprecedented damage of forest plantations by pests and diseases. The goal of the workshop was to develop a national insect pest and diseases management programme. However, the soil was known to be a reservoir or nursing medium for many of the forest pests and disease problems. It was thus agreed that besides other aspects, soil studies should be an integral part of the programme. Among the several objectives of the programme, an overview of insect pests, diseases and soil problems in forest plantations in the country was found pertinent.

In order to be effective, it was deemed useful to specify plantations that needed immediate attention. After looking at the dimensions of the problems as observed in the identified priority plantations, it was

immediately realized that the interventions needed to be long lived and carefully guided. On that note, it was decided that a NFHF be formed, that would attend pests, diseases and soil problems as they emerge in the national forest plantations from time to time. This paper describes the range of pest, disease and soil problems addressed by the Forum.

PESTS, DISEASE AND SOIL PROBLEMS ADDRESSED BY THE FORUM

The following are some of the problems addressed by the NFHF. They are sub-sectioned as: Nature of the problem; steps adopted in addressing it; and findings and recommendations as per individual plantation.

Death of *Acacia melanoxylon* and Crooked Growth of *Grevillea robusta*, Meru/Usa Forest Plantation, Arusha

Nature of the problem

(i) *A. melanoxylon,* trees aged 10 years at Oldonyo Sambu Range (Compartment 60) were drying from the growing tip downwards until the whole tree dries away.

(ii) *G. robusta*, trees aged 10 years at Narok Range (Compartment 294) had unusual and crooked growth.

Steps taken to look into the problem

(i) Surveys were carried out in the affected compartments to record incidence and severity of the problem.

(ii) Samples were taken for laboratory analysis. For the case of *A. melanoxylon*, composite soil samples were taken 75 cm away from the trunk and 45 cm deep. For the case of *G. robusta* soil and bark samples were taken.

(iii) Samples were prepared and analysed in the laboratory. For soil samples, the focus was on soil pH, cation exchange capacity (CEC) and exchangeable Al^{3+} and Ca^{2+}. While, for plant samples the focus was on *Botryosphaeriaceae* species of fungi, which is known to produce the recorded symptoms.

Findings and Recommendations

(i) It was found that, in *A. melanoxylon*, the problem was dieback, with incidence of the problem estimated to be 80%.

(ii) The problem was observed in a compartment where *A. melanoxylon* was planted as a pure stand.

(iii) Soil analysis results showed that pH values ranged from 11.93 (strongly basic) to 6.64 (slightly acidic) against the normal requirements for *A. melanoxylon*, which grow best at neutral to slightly acidic soils, that is, pH 6.5 and below.

(iv) The problem was more physiological than phytopathogenic, suggesting that something was wrong with the soil. On the other hand, there was a possibility of the presence of hard pan, which physically impeded root growth.

(v) In *G. robusta*, the problem was stem canker. This caused oozing of copious gum exudation, stunted growth and stem bending. In Narok, the incidence was estimated to be more than 90%;

(vi) To address the *A. melanoxylon* and *G. robusta* problems, use of resistant cultivars/varieties it was recommended.

Death of *Pinus patula* - Shume Forest Plantation, Lushoto - Tanga

Nature of the problem

Pines in the plantation were dying and dead trees showed reddish coloured needles**.**

Steps taken to look into the problem

(i) A survey was carried out in the affected compartments to study incidence and severity of the problems.
(ii) Needle samples were collected for laboratory analysis.

Findings and Recommendations

(i) Walking along transects of about 100 m in nine different locations, approximately 9 dead trees were encountered giving an incidence of about 5%.
(ii) The problem caused isolated death of trees in the plantation.
(iii) Laboratory results showed that the isolated death of trees was caused by Armillaria root rot.

Survey in Meru, Shume and Sao Hill and West Kilimanjaro Forest Plantation Plantations -

Nature of the problem

The survey was not a result of specific problems invading the plantations. It came forth as an integral component of a project *'Enhancing capacity of TAFORI in the management of forest pests, diseases and soil problems in national forest plantations'.* Through the project, the NFHF visited three plantations (Meru, Shume and Sao Hill). The key motive was to get first hand insight of key forest pests, disease and soil problems that need immediate intervention.

Approach adopted during the visit

(i) The Forum members held discussions with the plantation personnel in each plantation on what they considered to be the most important problems in the plantations.
(ii) The Forum visited tree nurseries in each plantation and shared working experiences with nursery working staff on pest and disease problems.
(iii) The areas with productivity problems were visited.
(iv) Where further studies on a particular aspect were required, soil and plant samples were taken.

Findings and Recommendations

(i) Nurseries – the problems observed include the damage of young seedlings by cutworms and the emergence of mutant seedlings at Shume Forest Plantation.
(ii) Within plantations - One of the most important observations was the effect of taungya farming practice. The practice was highlighted as a cause of social problems between plantation managers and the surrounding communities; of diseases (especially the soil-borne), and different sorts of damage to forest trees.
(iii) It was recommended that Taungya practice has to be improved.
(iv) Another pest/disease problem observed was gummosis, a copious exudation of gums by trees usually caused by the *Botryosphaeriaceae* fungi.
(v) In Shume Forest Plantation, an observation was noted in which mature pine trees died and toppled over. Upon uprooting, the trees were found to have Armillaria rot symptoms.
(vi) In Sao Hill Forest Plantation, two main problems were found: Needle casting in young pines aged one year in Division 4 Kitasengwa Range, Mgololo. The trees had silvery/pale patches on the needles with lower needles at the base of canopy turning yellow then casting down; in severe cases affected needles gave brown dust when shaken.

(vii) Another problem observed was infestation of Pines aged 3 years by the Pine needle aphid, *Eulachnus riley* (*Homoptera: Lachnidae*). Associated signs on the affected plants included black soot making the trees look unsightly; some needles in the affected trees turned yellow; there was a loss of the main growing tip and the proliferation of lateral shoots at the top (Witches broom). The incidence of the problem was estimated to be 85%.

Invasion of unknown Insect Pest on *Olea capensis* in Meru Forest Plantation

Nature of the problem

It was reported that this highly valuable tree species was invaded by an unknown pest that threatens to decimate the range planted with this species. The damage involved defoliation and drying of trees aged approximately 53 years covering 458 Ha.

Steps taken to look into the Problem

(i) The first intervention was to visit the affected range to study the incidence and severity.
(ii) The next step was to identify the pest responsible for defoliation.

Findings and Recommendations

(i) From vantage points near the affected trees, the incidence of the problem was estimated to be over 90%. The trees looked like they were burnt all over!
(ii) Closer to the trees, severely affected trees were found. The leaves were chewed from the margins to the extent that in some, only midribs had remained. One tree was felled to reveal the topmost part of the canopy**.**
(iii) The other sign associated with the infestation was the appearance of webbing on the trunks and branches of the affected trees. The webbing was thought to protect larvae from predation. There was also a mat of shed leaves on the ground and lots of frass, suggesting the extent of damage. Samples of the insect stages including the webbing were collected, were briefly reared at TPRI and were then sent to the experts for identification**.**
(iv) The pest was new in the country's plantations and thus proper identification had to be done to pave way for its management. Many efforts were made, involving taxonomy experts (Smithsonian Institution, USA and University of Auckland, New Zealand). Through intensive molecular characterization, it is only in recent months that the defoliating insect was identified as larvae of the moth *Palpita sp* (*Lepidoptera*: *Crambidae*). Two other species were found to be associated with *Palpita sp*, namely *Cryptoblabes gnidiella* (*Lepidoptera: Pyralidae*) and *Problepsis sp*. (*Lepidoptera: Geometridae*) but their roles in the damage was not clearly known.
(v) Upon revisiting the site (Sakila Range), three months later the trees were found to be recovering from the infestation.

Death of young *Pinus patula* in Mbizi Forest Plantation, Sumbawanga

Nature of the problem

It was reported that 1 – 2 year-old pines in the newly established Mbizi Forest Plantation in Sumbawanga were dying, both in the field and in the nursery. The problem reportedly started in mid-November 2015, about two weeks following a heavy downpour in the area.

Steps taken to look into the problem

(i) A discussion was held with the Plantation Manager in order to get more information on the nature of the observed tree death.
(ii) The next step was to visit part of the plantation having the problem to study the incidence and severity.

Findings and Recommendations

(i) On-site observations revealed that the trees were not dying as such but had altered growth. Characteristic features of the observed (altered) growth included suppressed growth of the leading bud in both apical and lateral branches; tip death of the leading bud in apical parts and in lateral branches in some trees; emergence of light blue multiple leaders (split leader), which seemed to replace the suppressed leading buds; and shortened internodes, which made the whole tree look stunted. In some of the trees, death of growing tips was accompanied by an exudation of resin.

(ii) As observed, death of the tips was just one of the symptoms of the problem but it did not seem to lead to the death of the whole tree. Alongside these observations, there was no sign of any insect being involved in the problem – no bore holes, no chewing, no insect life stage found, and no frass that could be linked to the problem. The incidence of the problem was estimated to range from 36 to 80%. The severity on individual trees was variable, from moderate to severe. In every tree that had the defect, 30% of the crown looked normal.

(iii) Three hypotheses (perceptions) were advanced to describe the probable cause of the problem;

- The infection of the plant by phytoplasma, typical feature of which is the appearance of multiple branches, a condition which is referred to as a witches' broom.
- The infection of the plant by *Diplodia pinea* (syn. *Sphaeropsis sapinea*), typical symptoms of which are brown, stunted new shoots with short, brown needles, the presence of resin droplets and one or a few very short needles.
- Micronutrient deficiency, especially that of Boron, typical deficiency symptoms which include reduced growth rate (stunting), followed by cessation of and sometimes death of the growing point. The cessation of apical growth is accompanied by swelling of the stem apex followed by multiple branching.

(iv) Boron deficiency was considered as the most convincing cause of the problem. *Phytoplasma* are transmitted by insect vectors, and during the survey, no insect was encountered in the poorly growing pines. The infection by *Diplodia* was also discarded because symptoms of their infection in pines first appear on older branches while in the present case, altered growth appeared on the apical and younger lateral branches.

(v) Boron is known to influence the physiology of the plant, particularly growth. It is involved in cell division and influences apical dominance. The micronutrient is immobile within the plant and therefore, its deficiency symptoms are likely to start on younger tissues. Deficiency of Boron in pines suppresses apical dominance causing the formation of multiple branches; sometimes, critical deficiency of the micronutrient leads to death of the apical shoot. Some chemical and physical properties of soils and chemical properties of Boron minerals influence boron mobility within the soil and its availability to plants.

(vi) Soil samples around root zones of the affected plants and the analysis thereof revealed critical deficiency of Boron in the soils. The findings in this study showed the available Boron to be ranging from 0.05 – 0.17mg/kg. This was a critical deficiency as normal soils have Boron of the range of 3 – 6mg/kg.

(vii) As a way forward, it was suggested that Boron spray be applied along a narrow strip in areas where boron deficiency symptoms were detected. The use of the traditional fast release Boron fertilizer such as Borax (Sodium tetraborate) and slow release fertilizers such as Colemanite (Calcium borate) was recommended.

Death of *Pinus patula* in West Kilimanjaro Forest Plantation, Siha District - kilimanjaro

Nature of the problem

(i) It was reported that Pines aged 3 – 4 years in compartments 57 and 77B were dying of unknown cause and affected the areas previously planted with *Acacia melanoxylon* (*Fabaceae*) which could attribute to the problem.

(ii) The dying reportedly started in 2015, with the trees dying consecutively in patches; and that the dying usually started with yellowing of needles followed by dying of whole tree.

(iii) In addition, *Dovyalis caffra* (*Flacourtiaceae*) trees which were used for fencing in the nursery were also dying in patches.

Steps taken to look into the problem

(i) The Team visited the affected trees, both in the plantation and in the nursery. Some of the on-field observations were made, including soil sampling. Also samples of the bark in the butt of the affected trees were taken to generate further information about the problem.

(ii) The samples were taken to the laboratory for further investigation and analysis.

Findings and Recommendations

(i) In the nursery when the affected trees were uprooted, the root system was found to be dead and rotten. The basal part of the root system was black but further from the base, the affected stem had a whitish covering.

(ii) In the plantation, it was also found that the trees (Pines) were indeed dying in patches as reported, with the foliage turning yellow before dying. The incidence of the problem was estimated to be 15%.

(iii) Taungya was the dominating practice in the plantation. The plantation was cultivated all over, with crops (potato, carrot and garden peas) at different stages of growth.

(iv) After critical integration of field observations and laboratory findings; and after considering different possible hypotheses about the observed problem, it was concluded that the trees were killed by Armillaria root rot, a disease caused by a fungus *Armillaria sp*. (formerly *Agaricus melleus*).

(v) The pathogen is a facultative necrotroph. It colonizes living roots, kills root tissue and then utilizes the dead tissue as source of nutrition. The pathogen may infect roots of healthy trees by basidiospores and through rhizomorph contact (from diseased tissue). The disease (Armillaria root rot) is favoured partly by closer spacing, which enhances contact of healthy trees with rhizomorphs. A wider spacing is recommended.

Death of Cypress, (*Cupressus lusitanica*) in West Kilimanjaro Forest Plantation, Siha District - Kilimanjaro

Nature of the problem

(i) It was informed that Cypress trees aged 15 years in a 9 Ha Compartment 104, were dying. The problem was first observed in 2016.

(ii) The death of trees was isolated and gradual.

Steps taken to look into the problem

(i) A visit accompanied by some forest managers was made to the forest compartment where the trees were reported to have died, first viewed from a vantage point.

(ii) The researchers and managers then walked into the compartment, to capture the nature of the problem on individual trees – the parts affected and the extent of the effect, that is, the severity.

(iii) Some of the affected trees were uprooted to determine what was happening in the root system**.**

(iv) Using a machete, the bark of the affected trees was scratched at the basal parts to expose the appearance of the inner tissues.

(v) Bark samples from the basal parts of the affected trees were taken for further investigation in the laboratory to identify the disease.

Findings and Recommendations

(i) From vantage points in the field, trees were seen to be dying at different stages – some showing yellow canopies, others brown, and others typically dead.
(ii) Upon uprooting, it was found that the root system was infected, with some parts having the bark falling loose.
(iii) It was also found that some whitish substance typical of fungal mycelia was dispersed in the soil and around the infected root parts.
(iv) Scratching the bark at the soil level using machete also revealed a white parchment just beneath the cork, suggesting that *Armillaria* infection could be one of the causes of rotting.
(v) Subcultures from the ten (10) samples submitted to the laboratory gave rise to whitish and to slightly yellow fluffy mycelia.
(vi) Upon keeping the cultures for prolonged periods, structures typical of *Armillaria* rhizomorphs formed. The structures are typically black and root like, suggesting that the pathogen involved was likely to be *Armillaria* species.
(vii) It was strongly advised that trees in the affected compartment be harvested and put into whatever use, to avoid further loss.

CONCLUSION AND RECOMMENDATIONS

Managing soil borne diseases in the national forest plantations is a key to maintaining and enhancing productivity. Just as it requires systems approach to maintain resilience between forests and their native diseases, addressing challenges of the diseases at landscape scale requires concerted efforts by multistakeholders – researchers, plantation managers, and policy makers. When a researcher suggests an approach to managing a freshly identified disease, for example, plantation managers should look for the means of implementing the recommended practice instead of just forwarding the reports to higher management level or simply shelving them in the office.

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