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Review

Diseased palm removals as a strategy for the successful management of Weligama coconut leaf wilt phytoplasma disease of coconut in Sri Lanka

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Abstract

Weligama coconut leaf wilt disease is a seriously debilitating disease affecting coconut in the Southern province of Sri Lanka since 2006. It has been declared as a quarantine disease and the Coconut Research Institute of Sri Lanka identified removal of the diseased palms as the strategy to stop the further spread of the disease to the unaffected areas. Therefore, the diseased palms identification and removal program is in progress since 2008 in this area. Under this program 339,271 diseased palms have been removed. Because of this management strategy the disease is to date confined only to the Galle, Matara and Hambanthota districts in the Southern part of the country. After minimizing the disease pressure of the area, re-planting coconut with resistant varieties was identified as the viable long-term solution to combat the disease.

Keywords: diseased palm, coconut, phytoplasma, management

Introduction

Coconut (*Cocos nucifera)* is a major plantation crop in Sri Lanka, comprising 440,000 ha. Currently, Weligama coconut leaf wilt disease (WCLWD) is considered as the most devastating coconut disease in Sri Lanka, however still confined to the Southern province of the country. It was identified as a phytoplasma-associated disease through PCR and sequencing (Perera *et al*., 2012) in late 2006. This phytoplasma belongs to the 16SrXI group and the affected palms showed similar disease symptoms to the root wilt disease in the Kerala province of India (Solomon and Geetha, 1949; Wijesekara *et al*., 2008; Perera *et al*., 2012; Ramjegathesh *et al*., 2012).

Symptoms of the disease

The initial symptom of the disease is flaccidity represented by the loosing of the angular shape of the leaflets and the downward bending giving the frond ribs the appearance of an animal. The degree of flaccidity varies among fronds in the same palm and the first symptom can be observed in young fronds in the mid whorl (Figure 1). In addition, uneven yellowing and marginal necrosis of leaflets, frond tip breaking, mid whorl yellowing of fronds, inflorescence necrosis and young root rotting are the secondary symptoms of the disease. Those symptoms cannot be observed in all the affected palms and some palms in moderate to severe stages tend to show secondary symptoms. Also,

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Figure 1. A) WCLWD affected palm with the initial flaccidity symptom and frond tip breaking. B) WCLWD palm with flaccidity, uneven yellowing and marginal necrosis of leaflets. C) WCLWD affected palm with leaf rot disease.

the palms weakened by WCLWD are often prone to fungal invasions causing leaf rot that is a secondary disease of infected palms (Wijesekara *et al.*, 2008; Perera *et al.*, 2012). The symptoms can be easily used to identify WCLWD affected palms in the field. Also, a nested PCR test with phytoplasma-specific universal primers have been developed to determine the pathogen presence under laboratory conditions.

Vectors of the disease

Phytoplasmas are plant pathogens transmitted by phloem feeding insects of order Homoptera and Hemiptera. Mainly, leafhoppers and planthoppers were transmitting phytoplasmas among the plants (Hosts, 2009). The vectors of the WCLWD were identified as leafhoppers and planthoppers (Kumara *et al.*, 2015). In the Sri Lankan context, nine insect species were identified as putative vectors by molecular techniques based on polymerase chain reaction (Kumara *et al.*, 2015). *Proutista moesta* and *Stephanitis typica* have been reported as vectors of the Kerala root wilt disease in India (Solomon and Geetha, 1949) but they need further confirmation to prove them as natural vectors. They are abundantly found in the Southern province and other coconut growing areas in Sri Lanka and were confirmed as vectors of WCLWD by transmission studies conducted in insect proof net houses (Kumara *et al.*, 2015) the PCR testing was able to detect nine putative vectors (Figures 2 and 3).

Spreading pattern of the disease

Although there was no proven evidence for the emergence of the disease in Sri Lanka, it is believed to be through the sea route from India surrounding the fisheries harbors in the Weligama area in Southern province of the country. Also, in most of the areas, high disease incidences were observed near coastal areas (Gunasena *et al.*, 2013). To identify spatial and temporal distribution of WCLWD in the Southern province, Geographical Information System (GIS) based remote sensing was effectively used for diseased palms identification and evaluation, especially in

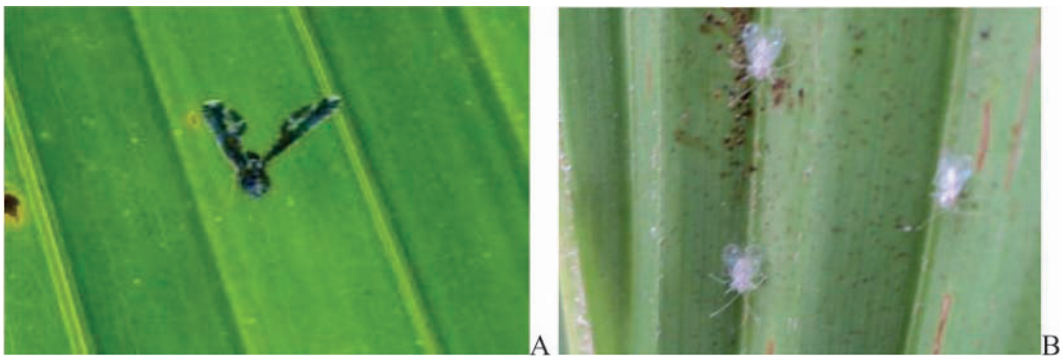

Figure 2. A) *Proutista moesta.* B) *Stephanitis typica.*

Figure 3. Insect proof net houses used for studies on insect vectors.

severe stages with intense yellowing but the system was not effective for palms and seedlings in mild to moderate stage (Nainanayake *et al*., 2016).

A study was conducted to identify palm to palm spreading pattern by selecting sites of 1 ha size from each mildly, moderately and severely disease affected zones in the Southern province of Sri Lanka. All the palms within the 1 ha block in each site were marked and mapped to assess the disease status. Symptom recording and mapping were done at 6 months intervals. Also, new symptomatic palms/seedlings were found in all experimental sites, and this may be due to new infections or to emerging palms/seedlings after the incubation period of the disease. Also a few new symptomatic palms could be observed at the vicinity area outside the selected blocks in all the experimental sites. The site selected from a severely disease-affected area had a greater number of new symptomatic palms than the other sites. Also, the results of the experiment revealed that WCLWD is a slowly spreading disease. No specific disease spreading pattern was observed during the experimental period in all three sites but it was observed a pattern somewhat similar to those of the insect vector transmitted diseases.

Disease distribution and severity

The total disease-affected area in the Southern province is about 22,925 ha. It is nearly 48% of the total land area under coconut cultivation in this province. Also, it is nearly 5% compared to the total land area of 440,000 ha under coconut in the country (Pathiraja *et al*., 2013). The coconut triangle is the country's mostly coconut cultivating area comprising more than 200,000 ha. Currently, the disease is not found within the coconut triangle area. The disease was not evenly distributed among the three districts in the diseased zone and the protective zone. Also, the disease incidence and severity vary among affected areas of the country. Matara district was the most severely affected area compared to Galle and Hambanthota districts. In Matara district out of 16 administrative divisions, 12 are affected. In Galle out of 19 and in Hambanthota out of 12 4 divisions were found to be affected, respectively. Nearly 67%, 46% and 28% of the coconut cultivable areas in Matara, Hambanthota and Galle districts were found to be affected by the disease, respectively. Totally the WCLWD has spread in 702 administrative subdivisions within 20 divisional secretary divisions in the Southern province of the country (Figure 4).

Disease management strategies

In 2007, a preliminary survey was conducted by in the Southern province of the country and nearly 340,000 disease palms have been reported to be infected over an area of 22,935 ha in three administrative districts

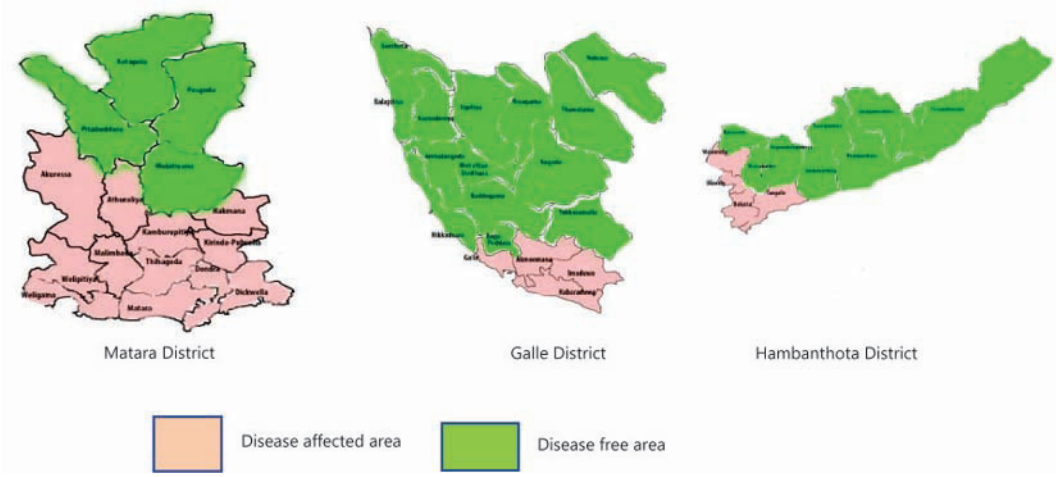

Figure 4. Disease distribution among divisional secretary divisions in affected districts.

of the Southern Province. Hence, a policy decision has been taken to remove all the affected palms from endemic areas and to maintain a disease-free boundary zone (protective zone) encompassing the endemic area to prevent further spread of the disease outside the boundary and within the endemic areas to healthy palms. For this purpose, a boundary zone of 3 km wide and 86 km long was demarcated, surrounding the endemic area. All the diseased palms in the boundary zone are being removed by continuous inspection.

During the 2008-2010 period, removing severely affected palms only in the protective zone, treating leaf rot affected palms with fungicides, and adopting the best agronomic practices for mild-moderately affected palms were recommended and practiced. But this strategy was unsuccessful due to the rapid increase of diseased palms in the endemic areas. Therefore, after 2010, a management decision was taken to remove all the affected palms in endemic and in the protective zone by regular field inspections without taking into consideration the disease severity of individual palms. Also, treating leaf rot-affected palms with fungicides was stopped, and it was decided to remove all the leaf rot-affected palms too from the area as it was found a secondary disease associated with WCLWD affected palms. Meanwhile, the transportation of fresh coconuts, fresh coconut husks, arecanut, and other ornamental palm species or live plant parts from plants belonging to family palmae out of the affected area beyond the protective zone was prohibited by a special government gazette notification to prevent the further spread of the disease (Figures 5 and 6). Also, WCLWD

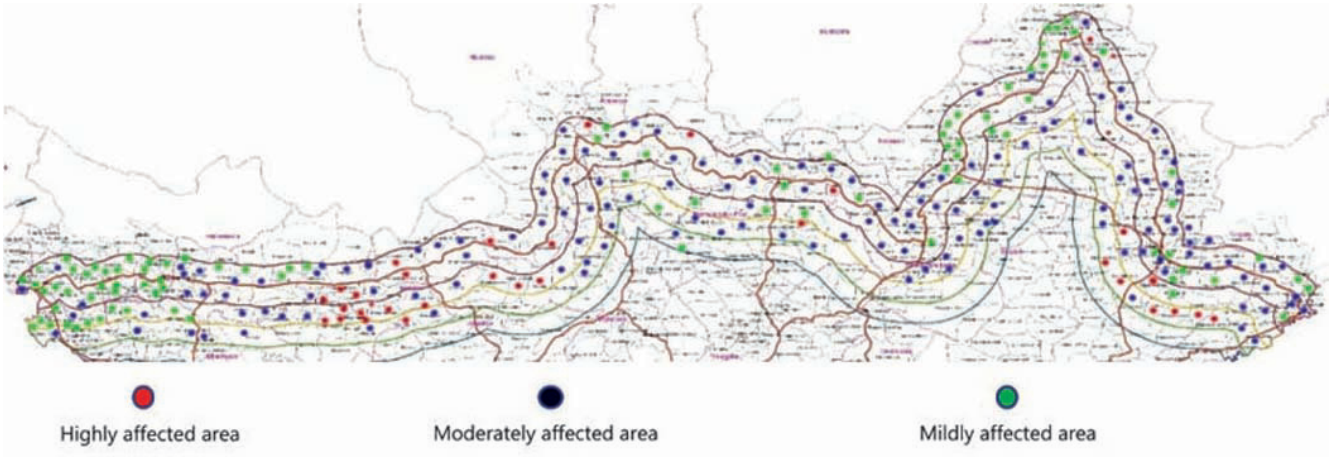

Figure 5. Disease severity in the protective zone.

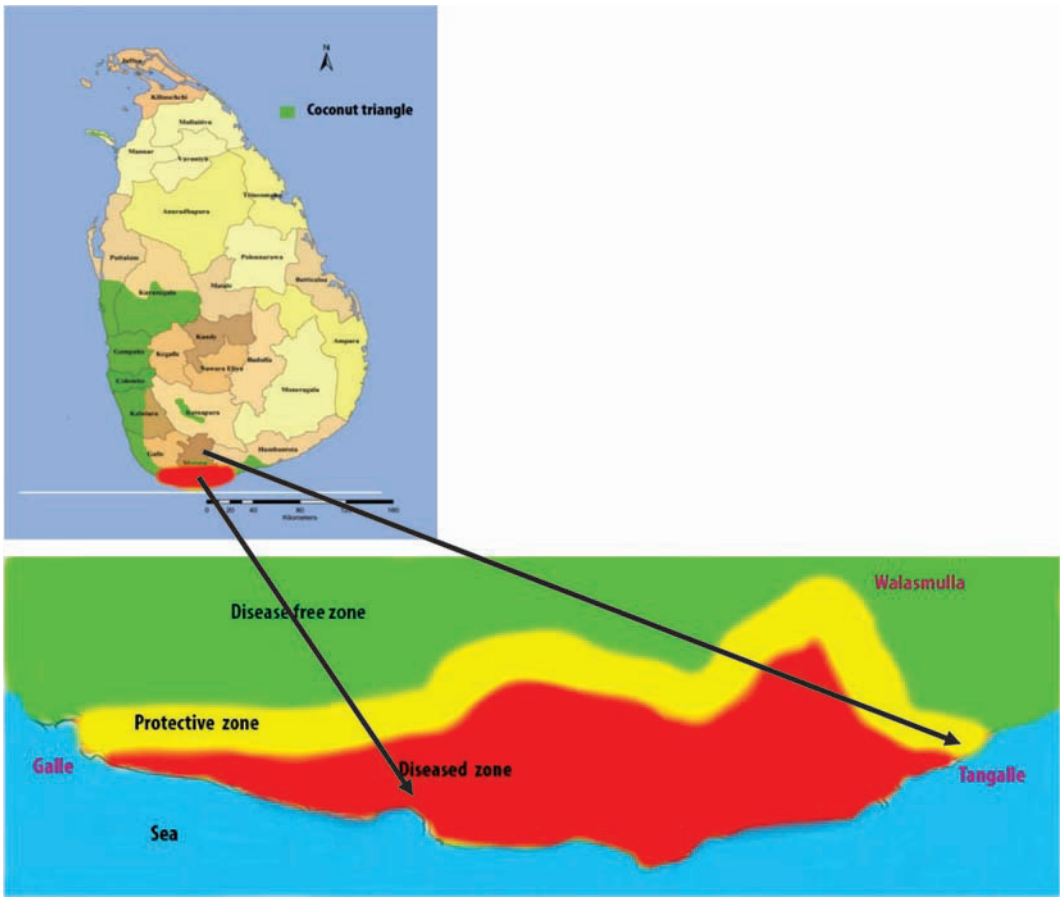

Figure 6. Diseased and protective zones for the WCLWD in the Southern province of Sri Lanka.

was declared as a quarantine disease in Sri Lanka and a few check points were established in the protective zone to implement the quarantine regulations and stop the illegal transportation of fresh plant materials from this area.

A field program has been launched since 2008 in the Southern province of the country to identify and remove the WCLWD affected palms. A group of inspectors has been working in this area for regular field inspections. Once they identified a symptomatic palm, it was marked, and a document was issued to growers advising them to remove those palms. After removing, a compensation payment is paid for palm removed by the government. Also, the removed palms were supplied with alternative crops such as cinnamon, pepper, and fruit crops to compensate the lost income due to coconut palm removals. Also, a series of awareness programs were conducted among growers, school children and government officers of the area to convince them about the importance of controlling the disease and avoid its spreading to the unaffected major coconut cultivating regions of the country. In addition, large number of printed materials were distributed among public, and several television and radio programs were also conducted.

Effect of the diseased palm removal

A continuous WCLWD affected palms identification and removal program has been in place in Southern Sri Lanka since 2008. During the 2008-2010 period, diseased palms were removed only in the protective zone. But from 2010 onwards, diseased palms have been removed in the protective zone and in the diseased zone. With the removal of diseased palms from the affected fields, inoculum is also removed, and this leads to the reduction of the inoculum potential. Normally, insect vectors acquire phytoplasmas from diseased palms and due to the palm removal, the

Table 1. Total number of diseased palms removed in three districts of the affected area (2008-2021).

District	Area under coconut (ha)	Disease affected area (ha)	Total number of diseased palms removed
Galle	12,500	3440	23,688
Matara	14,500	9752	303,533
Hambanthota	21,000	9733	12,050
Total	48,000	22925	339,271

inoculum is also removed from the field. This leads to the reduction of disease incidence and stopping the further spread. As reported in Table 1, 339, 271 diseased palms have been removed from this area of the country. It is also nearly a 15% out of the total coconut palms in this area. Also, the graph in Figure 7 shows the declining trend of disease incidence due to diseased palm removals during the last decade.

Under this program, diseased palms un-removed by the growers are destroyed by injecting the trunk with a systemic pesticide. In Sri Lanka trunk injection of 30 ml/palm of glyphosate or glufosinate ammonium is used and palms die within two weeks. Normally, phytoplasma diseases have an incubation period ranging from 8 months to two years. Therefore, this type of disease is very difficult to eradicate from affected fields within a short time. Because of the long incubation period and its vector transmission, continuous field inspection is needed for a long period of time to achieve a successful management level. Also, repeated field inspections in the whole affected area at least two times per year for two consecutive years will be beneficial in disease management aspect. In Sri Lanka, the disease has been currently kept under control and field programs have been reconsidered and reorganized to use this management strategy to achieve a much better management in the future. Because of this continuous diseased palm removal program, the disease has been confined to the country's Galle, Matara and Hambanthota districts.

Future disease management strategies and way forward

Although the successful management of the disease, it is necessary to introduce resistant varieties in this area for re-planting. Breeding for disease resistance will be a viable solution for this disease in the long run. The Sri Lankan Green Dwarf variety was found to be 98% resistant to WCLWD and a hybridization program is in progress using pollen collected from identified disease-resistant palms of Sri Lankan Tall variety

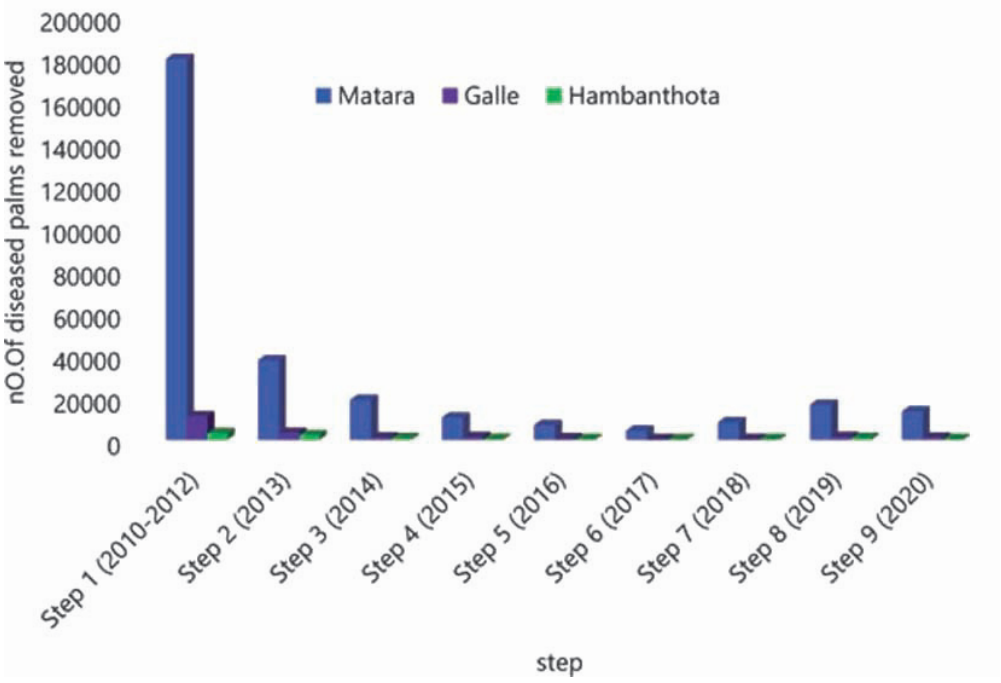

Figure 7. Comparison of diseased palm removals in three affected districts in the endemic area.

(Perera *et al*., 2015, 2016). Also, a mini seed garden has been established in Matara district in the disease-affected area to produce new hybrid coconut variety with higher disease resistance. Furthermore, newly produced hybrid variety has been planted in several sites in diseased areas to evaluate the degree of disease resistance under field level. Also, a variety screening trials have been established in the endemic area to identify resistant varieties from known existing coconut varieties. Meanwhile, palm removal program is being continued for further identification and removal of diseased palms emerging periodically to reduce the disease pressure in the area.

Acknowledgments

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