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# Assessment of spread of noxious Kongwa weed in Tanzania, using pathway risk analysis

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**ABSTRACT**

The noxious Kongwa weed (*Astripomoea hyoscyamoides* VatkeVerdc.) has been reported to cause enormous damage to crops and pastures in various parts of Tanzania, particularly Kongwa District of Tanzania. This paper assesses spread risk of potential pathways for the entry and spread of it in Kongwa District. The research progressed in two stages- with the first stage comprising a review of relevant local and international literature on the means of weed spread. Secondly, a household survey using a semi-structured questionnaire was conducted in Kongwa district to collect data on various land use practices that are associated with the spreading of the weed. Risk assessment framework containing six criteria was applied to the identified potential pathways. Pathway risk for each pathway was evaluated and assigned an intensity rating score through an analysis of the interviewee answers using Statistical Package for the Social Sciences (SPSS) software version 26. Results showed that, the most high-risk pathways were livestock movements and stock fodder transportation (81%) and agricultural produce and inputs (77%) which was attributed to the existing land use type in Kongwa. The medium risk pathways were farming tools, equipment, machines, footwear and clothing (75%) and water dispersal (56%). The low-risk pathways were wind dispersal (44%), construction activities (43%), escape from research sites (30%), ornamental plant trade (28%), tourism (25%) and introduction via exotic plant species (20%). Based on these findings, government and other stakeholders are advised to allocate weed preventive resources in the order of the threat level posed by a particular pathway.

## INTRODUCTION

Noxious weeds are large problem in many parts of the world, greatly affecting areas of agriculture, forest management, nature reserves, parks and other open space. *Astripomoea hyoscamoides* weed also known as Kongwa weed is one of the noxious weeds that have been reported to exist in Tanzania (Nkombe *et al.* 2018). The weed has been named Kongwa weed because of its severe infestation and apparent nativity in Kongwa district, Tanzania (Nkombe *et al.* 2018). *A. hyoscamoides* (Kongwa weed) is an annual dry land noxious weed having alternate simple leaves, white flowers with purple center and its height can reach up to approximately two meters at full maturity (Nkombe *et al.* 2018).

Nevertheless, because of its prolific growth, Kongwa weed has posed a serious threat to crop and forage production and subsequently affecting farmers' livelihoods (Mwalongo *et al.* 2020). Although the weed has been the subject of discussion among various media outlets and stakeholders, no studies have been conducted to ascertain the nature of its introduction and spread or to assess the relative risks of different pathways responsible for Kongwa weed spread in Kongwa district.

This study aimed to assess the risk posed by different potential pathways using a pathway risk analysis method. Pathway risk analysis method is a risk assessment approach which involves identifying a number of potential or possible pathways, assessing the threat that can be posed by each pathway and finally evaluating how each pathway can be managed with ease (Coleman *et al.* 2010). Pathway risk analysis method has proved to be an efficient way for identifying and ranking risk for various pathways, that have higher potential in spreading weeds in various areas of United States (Andow 2003), Victoria, Australia (King *et al.* 2008) and New Zealand (Williams *et al.* 2000).

## MATERIALS AND METHODS

### Study location and climate

The study was conducted in Kongwa district in the year 2020, where the interviews through a semi-structured questionnaire were conducted. Kongwa district is located between 5° 302 S and 6° 02 Slatitudes and 36° 152 E and 36° 02 E longitudes and is one of the seven districts making up Dodoma region in central Tanzania. Administratively Kongwa district comprises a total of 22 wards, 87 villages, 383 hamlets and 2 township authorities (URT, 2016). According to the 2012 Population and Housing Census, the population of Kongwa district was 309,973 (149,221 males and 160,752 females) (URT, 2013). The mean daily temperature in Kongwa district was 26.5°C with the highest temperature recorded being 31°C and the lowest temperature 18°C (URT, 2016). The district has a unimodal rainfall regime with the rainy season starting in December and ending in April. The average annual rainfall ranges between 500 and 800 mm (URT, 2016).

### Data collection procedure

In this study, two sources of data/information were employed; the first one was a review of relevant local and international literatures to identify possible pathways for weed spread in Tanzania. The second one was a house hold survey in Kongwa district using a semi structured questionnaire to collect information on the various land use practices for pathway risk assessment. During the survey, stratified random sampling method was used to select 120 respondents from 24 villages within Kongwa district. Respondents were stratified based on their land use category and were identified with the assistance of the Agricultural Extension Officers in their respective villages. The adopted land use categorization was agriculture, livestock and residential land because these are the main land use found over the area. Agricultural Extension Officers from Mtanana and Mbande villages and other 18 residents were purposely selected to act as key informants in this survey.

### Identification of pathways

Pathway has been defined as "any means that allows the entry or spread of a pest" (IPPC 2017). Studies by Mushi 2019, and Mtenga *et al.* 2019 have revealed the potential pathways that can cause weed spread in Tanzania.

### Pathway risk analysis

A quantifiable risk assessment framework was developed and then applied to all pathways. The method of ranking pathways basing on their risk score was adapted and modified from the work done by King *et al.* (2008). In this method, six main criteria were developed in order to formulate the risk assessment framework. The six main criteria and weightage assigned based on methodology of King *et al.* (2008) are given in **Table 1**.

### Risk assessment

Information from the conducted house hold survey was used to assess each criterion for every pathway, however the information needed to assess each criterion with respect to a certain pathway was not always available. In that regard the assessment was treated as missing data.

### Assigning intensity ratings and calculation of final pathway risk score for each pathway

Each pathway was evaluated for every criterion using the following intensity ratings: Low (L=0), Medium-Low (ML = 0.25), Medium (M=0.5), Medium-High (MH=0.75), High (H = 1.0). Whereby the High (H=1) rate indicates highest risk of the pathway in spreading the weed and the Low (L=0) rate indicates lowest risk of the pathway in spreading the weed. In the moments of missing information, the criterion was removed from the analysis.

To obtain the final pathway risk score for each pathway, the following formula was applied:

$$Pathway\ Risk\ score = \sum((average\ intensity\ rate) \times (criterion\ weight))......$$

(King *et al.* 2008)

Average intensity rate was obtained by taking the mean of intensity rating of all sub-criteria within a main criterion. Intensity rates were chosen from intensity rating score (*i.e.*, from H=1 to L=0). Criteria weights were obtained from **Table 1** (from lowest of 0.04 to highest of 0.4).

**Table 1. Weights of selected criteria (King *et al* 2008)**

| Criteria | Weightage (percentage) |
|---|---|
| Weed importance | 4 |
| Distance (Rapidity) | 8 |
| Introduction | 8 |
| Frequency of activity | 13 |
| Establishment | 40 |
| Management | 27 |

Furthermore, the pathways were further classified into three groups based on their risk percentage score as: High (>75%); Medium (54-75%) and Low (<54%) (King *et al* 2008).

## RESULTS AND DISCUSSION

The final risk score for each pathway is shown in **Table 2** in descending order.

**Table 2. Final risk score of different pathways**

| Pathway | Risk score (%) |
|---|---|
| Livestock movements and stock fodder transportation | 81 |
| Agricultural produce and inputs | 77 |
| Farming tools, equipment, machines, footwear and clothing | 75 |
| Water dispersal | 56 |
| Wind dispersal | 44 |
| Landscaping/Construction activities | 43 |
| Escape from research sites | 30 |
| Ornamental plant trade | 28 |
| Introduction via tourism | 25 |
| Introduction via exotic plant species | 20 |

**Table 3. Risk categorization for each pathway**

| Group | Pathways |
|---|---|
| High risk | Livestock movements and stock fodder transportation; Agricultural produce and inputs |
| Medium risk | Farming tools, equipment, machines, footwear and clothing; Water dispersal |
| Low risk | Wind dispersal; Landscaping/construction activities; Escape from research sites; Ornamental plant trade; Introduction via tourism; Introduction via exotic plant species |

The pathways were further classified as shown in **Table 3**. The introduction of noxious weeds in an area can be a result of the changes in environmental conditions of an area, accidental or intentional introduction through human activities and/or natural means such as water and wind dispersal (Bhowmik 2014).

Among the various investigated potential pathways, livestock movements and stock fodder transportation were found to be the pathways which posted the highest risk (81%) for the spread of the Kongwa weed as shown in **Table 2**. This result can be explained first by the nature of the major land use practice in Kongwa district which is largely mixed agriculture (URT, 2016) and second by the data collected during the interviewing of the land users in the infested land in Kongwa district. The interview results showed that 74.6% of livestock keepers use agro-pastoralism livestock keeping system, with 96.6% of them not taking any precaution to quarantine their livestock arriving from suspected infested lands and 100% of them not taking any hygienic measures to livestock before leaving suspected infested pasture land or before arriving in weed free areas. Livestock mobility and crop residue feeding have been used by pastoralists as drought coping strategies where animals get access to high quality forage resources and water (Vetter 2005). Livestock movement and stock fodder transportation have been reported to be the major pathway for the spread of weeds in agro-pastoral societies (Zhu *et al.* 2019).

The other pathway which posed high risk for the spread of the Kongwa weed was agricultural produce and inputs. Usually, Kongwa weed reaches maturity stage at the same time with most of the crops like maize, sorghum, millet and sunflower(*i.e.*, around April-June). Because of that, there is a greater risk of harvesting contaminated crops. This is supported by the results from the interviews which indicate that 70.9% of the farmers do not take any measures to control Kongwa weeds on their crop farms. Moreover, the results from the interviews indicate that 73.3% of the farmers use uncertified crop seeds. This may pose greater risk of planting seeds contaminated with Kongwa weed seeds because 79% of the farmers keep seeds from the previous harvest for the next growing season. Agricultural produce and inputs have been reported to pose greater risk for spreading weed seeds in several other studies (Rao *et al.* 2017).

Water dispersal (hydrochory) has been reported to be an important pathway for spreading weed seeds and propagules (Benvenuti 2007). Results from this study indicate that water dispersal pathway poses medium risk in the spread of Kongwa weed. This can be explained in part by the nature of the Kongwa weed seeds which have been observed (through field observations) to lack buoyancy, a property essential for seeds to float in water over long distances. Weed seeds need to have buoyancy characteristics to enable them to float in water over long periods of time and be transported over long distances (Fernández 2019 and Shi *et al.* 2020).

Farming tools, equipment, machines, footwear, and clothing have been assessed to pose medium risk for spreading Kongwa weed. This is apparent from the interview results which show that about 95.8% of all the land users in Kongwa district do not take hygienic measures on themselves and tools when entering or leaving infested lands. Kongwa weed seeds can attach themselves to clothing, or stick to footwear, farming tools, tractor tires or harvesting machines where they can be transported to other weed free areas and thereby start new infestation.

On the other hand, the wind dispersal pathway was assessed to pose low risk in spreading the Kongwa weed based on the biological characteristics of the Kongwa weed seeds. Weed seeds need to have special features such as lateral wings or pappus, hairs of feather and very lightseed weight for them to be able to be transported by winds over long distances

(Bryson and Carter 2004). Kongwa weed seeds are devoid of such characteristics. Furthermore, Kongwa weed seeds have been observed to fall very near to their plant stems and therefore very unlikely to be carried over long distances by wind (Nkombe *et al.* 2018). Other pathways that fell under the group of low-risk pathway are; landscaping/construction activities, escape from research sites, ornamental plant trade, introduction via tourism and introduction via exotic plant species. The major reason for these pathways to pose low risk was the low frequency of operation per year of these pathways (Randall 2014).

In an effort to prevent or reduce the spread of weeds, the first step invariably involves awareness of the various pathways at play in the spread of the weeds. This study results indicate the need for preventive measures to be initiated both at national and individual level because as always prevention is cheaper and much better than eradicating weeds after they have long established. At national level, there is a need for formulation of a national weed strategy with an objective to increase awareness of the impacts of the weeds to private and public land holders and establish a mechanism to effectively share early warnings information on introduction of noxious weeds. The strategy should also ensure proper cooperation and participation among government officials, farmers and other stakeholders in managing weeds across Tanzania's landscape. It is recommended for livestock keepers to reduce livestock movements through improved forage resources via pasture establishment or enclosure management.

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