

SHORT NOTE

Mango floral malformation in Kordofan, Sudan: Disease incidence and isolation of the causal agent

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Mango (*Mangifera indica* L.) is a unique species with respect to growth, nature and peculiar characteristics. In Sudan, area and production were 16238 ha and 651000 tons, respectively (MOAF, 2008). Like other crops, it is affected by many physiological and pathological stresses. Malformation disease of mango (MDM) was first reported in India in 1891 (Ploetz, 2001). It was also reported in Israel, Malaysia, Pakistan, Egypt, South Africa, Sudan, Swaziland and Uganda and the Americas (Brazil, El Salvador, Mexico, Nicaragua, the United States, and Venezuela) (Marasas *et al.*, 2006).

Mango malformation was first reported in Sudan in 1971 and was known as malformation of terminal bud growth in mango. This was expressed in the failure of the terminal bud of the affected shoot to grow normally and instead produced multiple shoots with very short internodes and rudimentary leaves (Abadi and Minessy, 1971). Mango malformation causes inflorescences to shorten, thicken and branch. It reduces flower number and size, increases the number of male flowers, and causes sterility or abortion in the remaining hermaphroditic flowers. Leaves may also develop within the inflorescence (Phyllody) (Marasas *et al.*, 2006). Vegetative malformation also occurs, particularly in young trees in nurseries. Shoots from apical and axillary buds are mishapen and have shortened internodes with dwarf and narrow leaves. As malformed inflorescence fails to produce fruits, yield losses may vary from 50 to 80% and in severe cases the loss may be almost total (Summanwar, 1967). The economic losses in Pakistan vary between 5 to 86% (Srivastava, 1998). Several fungi are associated with MDM, all of which are in the *Gibberella fujikuroi* species complex (i.e., *F. subglutinans* sensu lato) (Marasas *et al.*, 2006). Recent literature reveals the association of the fungus

Fusarium mangiferae (Britz, Wingfield and Marasas) to be the cause of the disease (Britz *et al.*, 2002). Disease manifestation by artificial inoculations has been proved (Freeman *et al.*, 1999). The objectives of the present study were to study the disease incidence and to determine the fungi associated with the malformed tissues and find out the cause of mango floral malformation in Kordofan, Sudan.

Field surveys for mango malformation disease

A survey was conducted during the flowering cycle (November-December, 2007) to study the incidence of mango malformation in north and south Kordofan. Five sites, namely Abu Karshola, Abu Geibaha, Alfayed, Almalbas and Tagmala were chosen randomly and three orchards were selected randomly from each site. Random samples of three trees of each grown cultivar, namely Taimour, Abusamaka, Galbetour, Hindi and Baladi from each orchard were selected. Sub-samples of five inflorescence clusters were collected from each tree. The disease incidence was calculated according to the following:

$$\text{Disease incidence (DI)} = \frac{N_1}{N_2} \times 100\%$$

where N_1 and N_2 represent the number of infected trees and total number of trees assessed for each cultivar, respectively.

Fungi associated with mango malformation disease in north and south Kordofan

To determine the fungi associated with mango malformation disease, random samples of three trees of c.v Baladi (seeded) from each orchard at each site were selected. Sub-samples of five inflorescence clusters were collected from each tree. Fourty five sub-sub-samples were surface disinfested in 1%NaOCl solution for 2 minutes, rinsed twice in sterilized deionized water, dried on sterilized blotting paper and placed onto 9 cm diameter Pyrex glass Petri plates containing potato dextrose agar (PDA) medium (Nelson *et al.*, 1983). The plates were kept for 7 days in a cooled incubator at 25° C under fluorescent illumination to give a 12 hour photoperiod to ensure maximum macro conidial production. Based on the observed cultural and morphological characteristics, the fungi isolated were identified following standard keys (Ellis, 1980; Nelson *et al.*, 1983).

Recovery of *F. mangiferae* from three exotic cultivars

To study the recovery of *F. mangiferae* from the exotic cultivars, three exotic cultivars, namely Tommy Atkins, Kent and Keitt were chosen from three different orchards in Khartoum State. Ten samples of each exotic cultivar were collected using the above mentioned method. The percent of infected tissues was recorded.

Disease incidence of mango floral malformation in five different sites in north and south Kordofan States revealed that the disease was widely distributed with 100% prevalence in the surveyed orchards. The results in Table 1 showed that the highest floral malformation incidence was observed in Abu Karshola site (40%), followed by Alfayed (38%) and Tagmala (34%), while Almalbas and Abu Geibaha sites showed the least disease incidence (32%). The overall mean of disease incidence in surveyed sites was estimated at 35.2%. All surveyed local cultivars were infected and Taimour showed the highest disease incidence (66%) followed by Galbetour (56%), Baladi (22%) and Hindi (26%), while the least incidence was observed on Abusamaka cultivar (6%). Three fungi viz. *F. mangiferae* (Britz, Wingfield and Marasas), *F. oxysporum* and *Colletotricum gloeosporioides* (Penz and Sacc), were found to be associated with malformed parts. Maximum recovery was exhibited by *F. mangiferae*. In Abu karshola site, 33% of samples were infected with this fungus while, Alfayed recorded the least infected samples (Table 2). Tissue assay of exotic cultivars revealed that maximum infection of 84% was caused by *F. mangiferae* in Tommy Atkins followed by 60% and 54% in Kent and Keitt, respectively (Table 3).

Table 1. Incidence of mango floral malformation disease (%) in local mango cultivars in five sites in north and south Kordofan (November–December 2007).

Sites	Cultivar					Mean (%)
	Taimour	Abusamaka	Galbetour	Hindi	Baladi	
Abu Geibaha	70	00	70	10	10	32
Abu Karshola	80	00	70	40	10	40
Alfayed	60	10	60	30	30	38
Almalbas	50	10	30	30	40	32
Tagmala	70	10	50	20	20	34
Mean	66	6	56	26	22	35

Table 2. Fungi associated with malformed parts of mango cv. Baladi (seeded) in north and south Kordofan

Sites	Fungi isolated	Samples infected (%)
Abu Geibaha	<i>F. mangiferae</i>	26
	<i>F. oxysporum</i>	2
Abu Karshola	<i>F. mangiferae</i>	33
	<i>F. oxysporum</i>	4
Alfayed	<i>F. mangiferae</i>	22
	<i>F. oxysporum</i>	2
Almalbas	<i>F. mangiferae</i>	24
	<i>C.gloeosporioides</i>	2
Tagmala	<i>F. mangiferae</i>	28

F=*Fusarium* and *C*=*Colletotricum*

Table 3. Percent infection by *F. mangiferae* in three exotic cultivars

Cultivar	Total samples examined	Infected samples	Infection (%)
Tommy Atkins	50	42	84
Kent	50	30	60
Keitt	50	27	54

The present study was aimed to determine the fungi associated with floral malformed tissues of local cultivated in some mango growing areas of greater Kordofan. Also, incidence of the disease was assessed. The considerably high incidence of floral malformation in mango orchards in greater Kordofan (32%-40%) with an average infection level of 35.2% is considered a serious problem of mango production. Although mango malformation was reported in the Sudan since 1971, the isolation of the causal agent was not done before. The fungus *F. mangiferae* proved to be the dominant fungus infecting the majority of the tissues. The infection percentage of other fungi remained low (Table 2). The infection percentage (within tissue infection) of *F. mangiferae* confirms its role in causing of malformation symptoms. The pathogenic interaction with floral buds resulted in high incidences of

malformation which started early in the floral season, extended up to early February and was re-established in August.

The fungus *F. mangiferae* was often associated with the floral and vegetative apices. This is similar to the results reported by Ploetz (1994) in USA. Frequent recovery of *F. mangiferae* from malformed trees grown in different ecological zones of the world had already been proved. As

malformed shoots show elevated levels of infection but non malformed ones show the least pathogenic association, it is suggested that symptom manifestation occurs only after massive colonization by the fungus *F. mangiferae* (Ploetz and Gregory, 1993). The exotic cultivar Tommy Atkins showed maximum infection of 84% caused by *F. mangiferae* and this is in line with the findings of Iqbal *et al.* (2006), who found that Tommy Atkins showed the highest recovery of *F. mangiferae* among three tested exotic cultivars.

Apparently, mango floral malformation has become a wide-spread and potentially destructive disease in greater Kordofan. So, further studies on assessment and epidemiology of the disease are needed.

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التشوه الزهري في المانجو بولاية كردفان، السودان: نسبة المرض وعزل المسبب المرضي

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الخلاصة

أجريت هذه الدراسة لمسح التشوه الزهري في المانجو في ولاية كردفان، السودان خلال العام 2007م. تم مسح خمس مواقع. لم يوجد بستان خالي من الأزهار المشوه. أعلى نسبة للمرض سجلت بموقع ابوكرشولا (40%) تلتها الفيض (38%) وتجملا (34%) و لوحظت أقل نسبة للمرض في موقعي أبوجبيهة و الملبس. كان متوسط النسبة العامة للمرض في كل مواقع المسح 35.2%. كل الأصناف المحلية التي تم مسحها مصابة و أظهر تيمور أعلى نسبة للمرض (66%) و تلاه قلب التور (56%)، هندي (26%) و هو الفطر *Fusarium mangiferae* بلدي (22%) بينما لوحظت أقل نسبة للمرض على صنف أبو سمكة (6%). ثبت أن فطر الشائع في كل العينات المصابة بنسبة 100% في كل مناطق المسح الخمس. أظهر الصنف المستورد تومي أتكنز نسبة إصابة أكثر من الأصناف المستوردة المختبرة معطياً 84% من الأنسجة المصابة.